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# **AERONAUTICAL ENGINEERING**

**A SPECIAL BIBLIOGRAPHY  
WITH INDEXES  
Supplement 6**

**JUNE 1971**

**CASE  
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**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

# PREVIOUS BIBLIOGRAPHIES IN THIS SERIES

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NASA SP-7037 (01)	January 1971	Sept.-Dec. 1970
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NASA SP-7037 (04)	April 1971	March 1971
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# AERONAUTICAL ENGINEERING

## A Special Bibliography

### Supplement 6

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in May 1971 in

- *Scientific and Technical Aerospace Reports (STAR)*
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# INTRODUCTION

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This supplement to *Aeronautical Engineering—A Special Bibliography* (NASA SP-7037) lists 534 reports, journal articles, and other documents originally announced in May 1971 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*. For previous bibliographies in this series, see inside of front cover.

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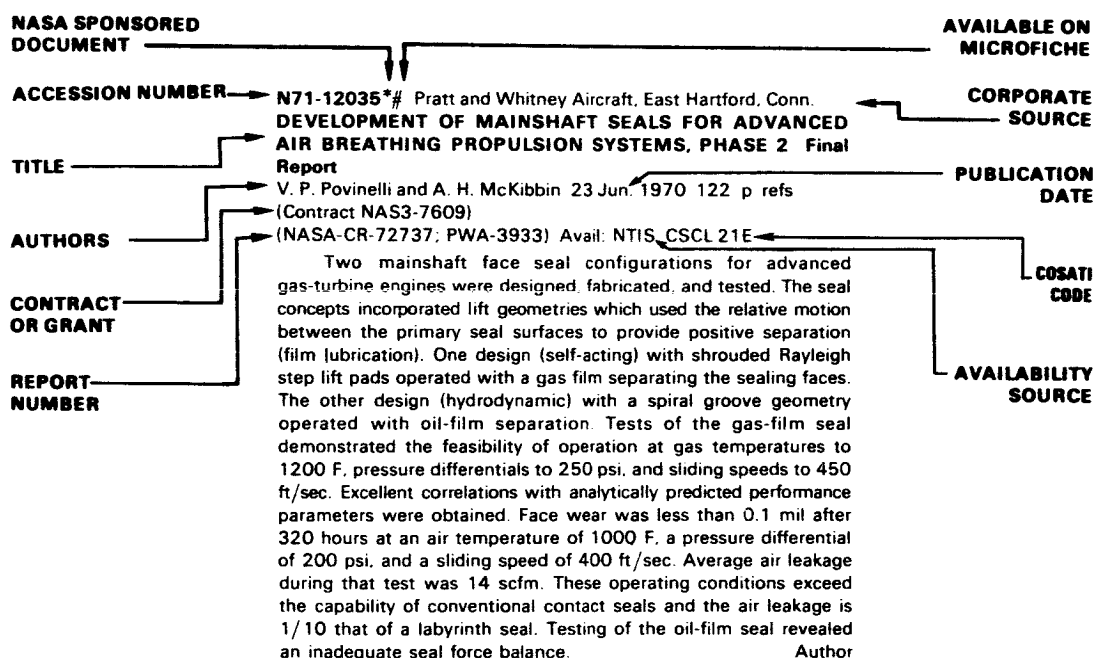
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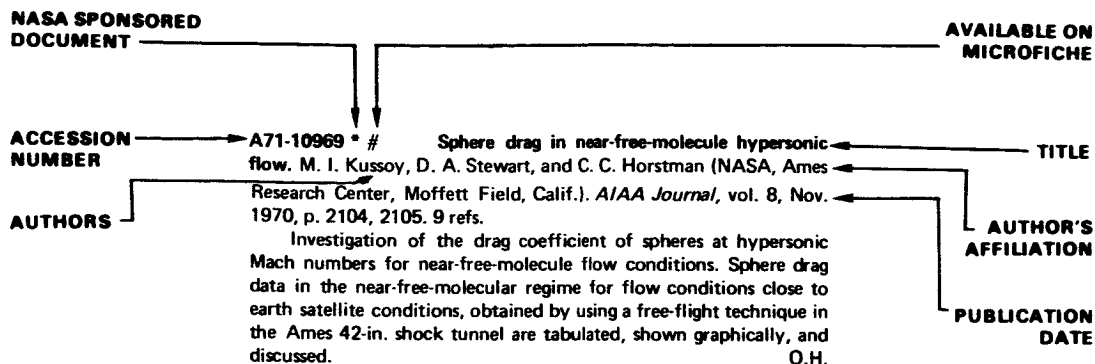
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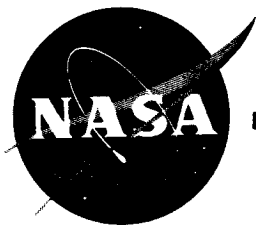
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# AERONAUTICAL ENGINEERING

A Special Bibliography (Suppl. 6)

JUNE 1971

## IAA ENTRIES

**A71-22078 # Flutter analysis of rotating cylindrical shells immersed in a circular helical flowfield of air.** A. V. Srinivasan (United Aircraft Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.). *AIAA Journal*, vol. 9, Mar. 1971, p. 394-400. 13 refs.

The aeroelastic stability of a long, thin cylindrical shell with the outer surface exposed to an inviscid, helical flow of air is investigated. The cylinder behavior is described by classical shell equations, whereas the aerodynamic forces are described by the linearized potential theory. The approach that is used herein examines the nature of stability of the system when the system is 'slightly' perturbed from its initial equilibrium state. In this paper, numerical results are presented only for the special case of swirl flow around a nonrotating shell, i.e., the axial flow velocity is set to zero. These results indicate that traveling wave type of flutter can be caused by coalescence of backward and forward traveling waves. Two approximate theories are presented and the results are compared.

(Author)

**A71-22080 \* # Analysis of nonlinear panel flutter and response under random excitation or nonlinear aerodynamic loading.** Franklin E. Eastep (USAF, Institute of Technology, Wright-Patterson AFB, Ohio) and Samuel C. McIntosh, Jr. (Stanford University, Stanford, Calif.). *AIAA Journal*, vol. 9, Mar. 1971, p. 411-418. 10 refs. Grant No. NGR-05-020-102.

Since the exact solution to von Kármán's large deflection equations is unknown, the Rayleigh-Ritz approximation to Hamilton's variational principle is used to investigate nonlinear panel flutter. Solution to this problem is given for (1) random excitation and linear aerodynamic loading, and (2) nonlinear aerodynamic loading alone. For 1, the limit-cycle oscillation is determined by representing the modal amplitudes by a Fourier series and applying the Galerkin averaging for the temporal solution. The existence of a limit cycle is determined by investigating the stability of small perturbations about the limit cycle solution. Random excitation provided by a known pressure with spatial and temporal random variation is introduced and treated. For 2, a two-dimensional panel with aerodynamic loads obtained from nonlinear piston theory is examined. A coupled set of quasi-linear second order differential equations in time is derived for the modal amplitude. These equations are then integrated from given initial conditions to provide the panel motion versus time. The importance of various nonlinear aerodynamic terms is assessed and the implication of the significant

terms with respect to panel stability and postcritical response is discussed. (Author)

**A71-22081 \* # Stochastic properties of turbulence excited rotor blade vibrations.** Gopal H. Gaonkar and Kurt H. Hohenemser (Washington University, St. Louis, Mo.). (American Institute of Aeronautics and Astronautics, Atmospheric Flight Mechanics Conference, Tullahoma, Tenn., May 13-15, 1970, Paper 70-548.) *AIAA Journal*, vol. 9, Mar. 1971, p. 419-424. 14 refs. Contract No. NAS 2-4151.

The developed analytical methods are applicable to the linearized equations of blade motion up to high rotor advance ratios. Rigid flapping blades with elastic flapping restraint are stipulated, only vertical turbulence components are considered and the ratio of turbulence scale length over rotor radius,  $L/R$ , is assumed to be large. On the basis of computed threshold crossing expectations the blade response can be described as a quasi narrow band random process with small phase angle variance. The limiting case of infinite  $L/R$  is easy to compute and to interpret and yields conservative values for the mean square blade response. Numerical analysis for a slowed unloaded rotor based on low altitude turbulence data indicates in the absence of gust alleviating devices an appreciable probability of excessive blade flapping or flap-bending. (Author)

**A71-22083 # A theory of the high-aspect-ratio jet flap.** Keith P. Kerney (Cornell University, Ithaca, N.Y.). *AIAA Journal*, vol. 9, Mar. 1971, p. 431-435. 8 refs. Contract No. AF 49(638)-1346.

The method of matched asymptotic expansions, which Van Dyke used to formulate a lifting-line theory for high-aspect-ratio wings, is applied to a wing with jet flap. The development differs from Van Dyke's in that velocity components instead of the velocity potential are the dependent variables, thin-airfoil approximations are used throughout, and the jet flap is present. The theory is given for the case of a flat elliptic wing with spanwise-uniform jet-momentum coefficient and jet angle and the result is a simple equation for the lift coefficient. Comparison with the results of two earlier finite-aspect-ratio jet-flap theories shows close agreement. Certain approximations needed in the earlier theories to solve the integral equation for the upwash induced by a semi-infinite lifting surface are avoided by consistent use of the principle that, in the limit as the aspect ratio becomes infinite, the change in lift due to induced incidence is much smaller than the lift, so that the integral equation does not have to be solved. (Author)

**A71-22084 # Strong blowing into supersonic laminar flows around two-dimensional and axisymmetric bodies.** G. R. Inger and G. A. Gaitatzes (McDonnell Douglas Astronautics Co., Santa Monica, Calif.). (American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, Los Angeles, Calif., June 24-26,

1968, Paper 68-719.) *AIAA Journal*, vol. 9, Mar. 1971, p. 436-443. 23 refs. Research supported by the McDonnell Douglas Independent Research and Development Fund.

Investigation of a generalized boundary-layer model of the flow around high-speed slender bodies with surface mass transfer, for injection rates ranging from classical transpiration-cooled boundary-layer values to very large rates where blowing momentum and lateral pressure gradient effects are important. The model consists of the usual boundary-layer axial momentum and energy equations plus the inviscid form of the lateral ( $y$ ) momentum equation; the combined effects of viscosity, compressibility, lateral pressure gradients, and three-dimensional transverse curvature with blowing and viscous-inviscid interaction are considered. An approximate integral-method solution of these equations is obtained and applied to the case of uniform massive blowing on supersonic semiinfinite wedges and cones where the dividing streamline becomes straight. Results are presented for the blowing effect on the streamline pattern, induced pressure field, and blown gas layer thickness, including comparisons with available experimental data. (Author)

**A71-22088 # Laminar boundary layer on a cone at incidence in supersonic flow.** R. R. Boericke (General Electric Co., Re-Entry and Environmental Systems Div., Philadelphia, Pa.). (*American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 8th, New York, N.Y., Jan. 19-21, 1970, Paper 70-48.*) *AIAA Journal*, vol. 9, Mar. 1971, p. 462-468. 39 refs. Research supported by the General Electric Co.

Results of three-dimensional boundary layer calculations for a pointed cone are presented and extensive comparisons with experimental data are made. Using a similarity transformation first proposed by F. K. Moore, the explicit dependence of the equations on axial position is removed. A further transformation is made to remove a singularity at the leeward symmetry plane. The resulting equations, in two independent variables, are then solved with an implicit finite difference technique by marching around the cone from the windward to the leeward symmetry plane. For the first time, comparisons of the theory with test data are given. These demonstrate the validity of the approach and include cases with large cross flow. The comparisons include heat transfer, pitot probe measurements, separation line location, and effects of blowing. A technique for computing the edge properties from an experimental pressure distribution is developed. Heat transfer measurements are predicted to within 6% using this technique. The comparisons with experimental data demonstrate that the boundary layer equations, in similarity form, provide an adequate representation of the viscous flow over most of the cone surface, although the physical model breaks down near the leeward symmetry plane. Together with a numerical procedure (such as Moretti's) for solving the inviscid flow, this approach can be used with confidence to predict viscous flow properties on cones at angle of attack within the region of validity of the usual boundary layer assumptions. (Author)

**A71-22089 # Investigation of injectant properties on jet penetration in a supersonic stream.** R. E. Reichenbach (Aerospace Corp., El Segundo; U.S. Naval Postgraduate School, Monterey, Calif.) and K. P. Horn (Aerospace Corp., Plasma Research Laboratory, El Segundo, Calif.). *AIAA Journal*, vol. 9, Mar. 1971, p. 469-472. 17 refs. Contract No. AF 04(695)-69-C-0066.

Experimental investigation of the effect of liquid properties on secondary injection from a single small-diameter nozzle in a supersonic stream. Normal penetration of liquid jets was inferred from scattered-light and schlieren photographs. Primary flows with incident Mach number of 2.8 and 4.0 were produced in a 4 x 4-in. blowdown wind tunnel. Data on normal penetration of room-temperature water were used to extend published correlations to lower injection pressure ratios. The effect of vapor pressure on penetration was investigated by injecting superheated water and acetone. Penetration height was correlated with injection pressure ratio for superheated liquid injection; these data were compared with

room-temperature results. Vapor pressure breakup outside of the spray nozzle had little effect on the penetration height. Liquid viscosity and surface tension were varied over a wide range of conditions; neither property affected the penetration height for flow in the acceleration-wave breakup regime. (Author)

**A71-22090 \* # Comparison of free-flight experimental results with theory on the nonlinear aerodynamic effects of bluntness for slender cones at Mach number 17.** Gerald N. Malcolm and John V. Rakich (NASA, Ames Research Center, Moffett Field, Calif.). (*American Institute of Aeronautics and Astronautics, Atmospheric Flight Mechanics Conference, Tullahoma, Tenn., May 13-15, 1970, Paper 70-554.*) *AIAA Journal*, vol. 9, Mar. 1971, p. 473-478. 19 refs.

Study of the aerodynamic effects of bluntness on slender cones, using free-flight tests of blunted 12.5 deg cones at Mach 17 and 18 together with the results of recent theoretical calculations. Conventional wind-tunnel tests for 10-deg cones at Mach 10.6 were also included. Results of comparisons show that there is a strong dependence of the initial moment-curve slope on nose bluntness. This dependence is accurately predicted by recent theoretical calculations using the method of characteristics both at zero angle of attack and at angles up to 5 deg. Some disagreement between theory and experiment is observed for low bluntness ratios. Strong nonlinearities in the pitching moment curve with angle of attack occur for blunted cones. The lift coefficient varies with bluntness and angle of attack in a manner similar to the pitching moment variation. T.M.

**A71-22091 \* # Experimental investigation of the mean flow of the laminar supersonic cone wake.** Dennis K. McLaughlin (Oklahoma State University, Stillwater, Okla.), James E. Carter (NASA, Langley Research Center, Hampton, Va.), Morton Finston (MIT, Cambridge, Mass.), and J. Alan Forney (NASA, Manned Space Flight Center, Aerophysics Div., Huntsville, Ala.). *AIAA Journal*, vol. 9, Mar. 1971, p. 479-484. 25 refs. Contract No. AF 44(620)-69-C-0013.

Experimental study of the mean flow of the near wake of a sharp, 7 deg half-angle, adiabatic cone at Mach number 4.3 and freestream Reynolds numbers of 40,600 and 94,300. The cone was supported by a five-degree-of-freedom magnetic model suspension system. Measurements were made of pitot pressure, static pressure (using both cone and cone-cylinder static pressure probes), and recovery temperature of a hot-film probe in the near-wake region between the model and six model diameters downstream. This enabled the flow regions to be mapped and a complete determination to be made of the flowfield properties at the measurement stations excluding the interior region of the recirculation bubble. The near wake was fully laminar at a Reynolds number of 40,600, and at the higher Reynolds number of 94,300 the flow downstream of the recirculation region underwent transition to turbulence. When compared with hypersonic cone wake measurements, it was shown that the recirculation region was two or three times longer at the lower Mach number, and the pressure overshoot peculiar to the hypersonic cone wake was not found in the present measurements. (Author)

**A71-22097 \* # Mach disk in underexpanded exhaust plumes.** Michael Abbett (Aerotherm Corp., Mountain View, Calif.). (*American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 8th, New York, N.Y., Jan. 19-21, 1970, Paper 70-231.*) *AIAA Journal*, vol. 9, Mar. 1971, p. 512-514. NASA-supported research.

Theory which predicts when and where a Mach disk forms in an underexpanded exhaust plume. The flowfield is qualitatively divided into two subregions—a quasi-one-dimensional core flow and the outer flow. The expansion waves from the exhaust plane reflect as compression waves which coalesce to form the intercepting shock. The integrated effect of the compression waves can result in the need downstream for a very strong adverse axial pressure gradient. The

supercritical (supersonic) core flow, interacting with the supersonic outer flow, cannot smoothly generate this adverse axial pressure gradient, but rather jumps to a subcritical (subsonic) state via a strong shock, the Mach disk. The Mach disk location is quantitatively determined by the requirement that the subsonic core flow must pass smoothly through a throat-like region, thereby becoming supersonic. Quantitative results are presented to illustrate the interaction and to verify the theory. (Author)

**A71-22098 # Forces on an inclined circular cylinder in supercritical flow.** W. J. Bootle (Avco Corp., Avco Systems Div., Wilmington, Mass.). *AIAA Journal*, vol. 9, Mar. 1971, p. 514-516.

A semiempirical method for estimating supercritical force coefficients at low cross Mach numbers consistent with the observed behavior is presented. An element of an infinite circular cylinder inclined at an angle of attack to the flow is considered. It is assumed that in turbulent flow the boundary layer exhibits negligible cross flow with respect to the inviscid streamlines. An empirical expression describing the pressure drag of elliptic sections in fully turbulent flow is presented, and a graph is obtained showing the pressure drag in supercritical flow as a function of chord/thickness ratio. A comparison of theoretical and experimental values for cross-flow force coefficient as a function of angle of attack shows excellent agreement. G.R.

**A71-22103 # Bounds for the torsional rigidity of heated beams.** Bruno A. Boley (Cornell University, Ithaca, N.Y.). *AIAA Journal*, vol. 9, Mar. 1971, p. 524, 525. 8 refs. Navy-supported research.

It is pointed out that the simplest such bound can be obtained by recalling that the thermoelastic stress in a beam under arbitrary temperature distributions cannot exceed a value proportional to the maximum temperature difference within a cross section. Exact and approximate bounds are compared. The four thin doubly symmetrical cross-sectional shapes analyzed by Van der Neut (1958) for chord-wise temperature distributions are used for a discussion of the results. G.R.

**A71-22108 \* # Numerical solution of boundary-layer flows with massive blowing.** Philip R. Nachtsheim and Michael J. Green (NASA, Ames Research Center, Thermal Protection Branch, Moffett Field, Calif.). *AIAA Journal*, vol. 9, Mar. 1971, p. 533-535. 9 refs.

For the case of blowing into boundary layers in stagnation regions, there is a dividing streamline where the oncoming flow is stopped by the injected flow. A method that incorporates the dividing streamline as the origin of coordinates is presented. The similarity variable is retained as the independent variable. With no blowing the dividing streamline coincides with the wall, and the coordinate system introduced reduces to the usual ones. Calculations performed using the proposed direct numerical method indicate that it is possible to integrate the boundary-layer equations under conditions of massive blowing irrespective of the value of the blowing parameter. Unlike the usual numerical methods, the proposed method actually converges to the solution more rapidly as the value of the blowing parameter increases. G.R.

**A71-22109 # Hypersonic strong interaction flow over an inclined surface.** T. K. Chattopadhyay and C. M. Rodkiewicz (Alberta, University, Edmonton, Alberta, Canada). *AIAA Journal*, vol. 9, Mar. 1971, p. 535-537. 5 refs.

The solution considered uses an asymptotic expansion in powers of the hypersonic interaction parameter to reduce the boundary-layer equations to a sequence of ordinary differential equations. The flowfield above an inclined plate in hypersonic viscous flow is examined. Zero-order equations obtained are solved by an iterative method. Some results are presented for  $Pr = 1$  and 0.72 with different thermal conditions on the plate. G.R.

**A71-22111 # New information on the two-dimensional jet interaction problem.** William J. Thayer, III (Boeing Scientific Research Laboratories, Seattle, Wash.). *AIAA Journal*, vol. 9, Mar. 1971, p. 539-541. 8 refs.

The two-dimensional flowfield considered results from the injection of a highly underexpanded jet from a converging slot nozzle perpendicular to a supersonic airstream. The boundary layer on the flat surface upstream of the nozzle is turbulent. An investigation of the two-dimensional, transverse injection flowfield has been carried out preliminary to supersonic combustion experiments in this flowfield. Hydrogen, helium and nitrogen have been injected perpendicular to a supersonic stream. Wall static pressure, concentration, and temperature measurements have been made upstream of these jets. G.R.

**A71-22112 Cessna Citation - First of the mini-fans.** Ralph Piper. *Business and Commercial Aviation*, vol. 28, Mar. 1971, p. 42-51.

Description of the design features, performance characteristics, systems, and flight evaluation of a business jet. The Citation twin jet has great versatility provided by the combination of a 400-mph-plus jet-style cruise and the airfield traits of a light twin. Its low wing provides a built-in ground cushion for touchdown at 80-85 knots. The jet will get into and out of over 800 airports that are inaccessible to most other business jets. The aircraft is easy to operate and routine to maintain. The Citation will be sold factory-direct from a series of sales-service centers to be set up in various parts of the US and possibly one in Europe. M.M.

**A71-22276 Simulation of a commercial satellite system in order to analyze the cost effectiveness of the system - Study of the Dioscures project (Simulation d'un système de satellites d'application en vue de l'analyse coût-efficacité de ce système - Etude du projet Dioscures).** B. Boucher de la Rupelle and C. Ganier. *L'Aéronautique et l'Astronautique*, no. 25, 1971, p. 63-70. In French.

Description of a cost-effectiveness study by simulation methods of the Dioscures project, which involves systems of telecommunications, air traffic control, and navigation by satellites. In particular, the number of launchings to be predicted as a function of the reliability of satellites is determined, as well as the choice of a policy for replacing these satellites. An attempt is made to show the advantages of such a method which, in addition to the accuracy of the data obtained, makes possible the study of several variants. F.R.L.

**A71-22278 Hypersonic aerodynamics (Aérodynamique hypersonique).** J. P. Gilly (Toulouse, Université, Toulouse, France), L. Rosenthal, and Y. Semezis (Société Nationale Industrielle Aérospatiale, Paris, France). Paris, Gauthier-Villars Editeur, 1970. 302 p. 194 refs. In French. \$11.75.

The purpose of this text is to inform and guide the aerodynamicist concerned with pilot projects which involve a hypersonic phase. In order to give a preliminary view of the field, the principal characteristics of hypersonic aerodynamics are given, with emphasis on their subsonic and supersonic origins. Concepts of aerothermochemistry are discussed, as well as equations of fluid dynamics, methods of calculation of hypersonic flows, the transfer of heat by convection, and heat transfer by radiation of gas. In an annex, some phenomena of wave interaction of boundary shock layers are discussed, the importance of which is particularly great at high Mach numbers, as well as at relatively low Reynolds numbers, and more so in the laminar than in the turbulent regime. F.R.L.

**A71-22372 # Approximate method for solving problems of aerodynamics of rarefied gases (Priblizhennyi metod resheniia zadach aerodinamiki razrezhennykh gazov).** V. I. Skakauskas. *Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia*, vol. 25,

Oct. 1970, p. 93-110. 8 refs. In Russian.

A method is developed for the approximate description of the steady motion of a rarefied gas consisting of Maxwellian molecules diffusely interacting with a surface. Applications to specific problems are presented in order to demonstrate the proposed method. One of these problems pertains to the flow around bodies of a rarefied gas filling the whole space. The other problem is concerned with an arbitrary, spherically symmetrical molecular interaction potential. Unsteady motion is also considered. M.V.E.

**A71-22405 # Determination of conical shock waves by the Padé-Shanks method (Détermination des ondes de choc coniques par la méthode de Padé-Shanks).** M. Bausset (Collège Scientifique Universitaire, Perpignan, France). (*Conférence Nationale de Mécanique Appliquée, Bucharest, Rumania, June 23-27, 1969.*) *Revue Roumaine des Sciences Techniques, Série de Mécanique Appliquée*, vol. 16, no. 1, 1971, p. 3-23. In French.

Study of the shape of a shock wave attached to the vertex of a cone of revolution or an elliptic cone moving steadily in a perfect gas at a high velocity. Using the Padé-Shanks method of fractional approximations, the case of a cone at zero angle of attack is considered, as well as the case of a cone at an angle of attack and the case of a yawing cone. The results are presented explicitly both for cones of revolution and for arbitrary cones of second degree. The limiting angle of attack, beyond which relaxation occurs, is determined. A.B.K.

**A71-22409 # Turbulent inflow into a convergent axisymmetric nozzle (Die turbulente Einlaufströmung in eine konvergente rotationssymmetrische Düse).** H. Limberg (Deutsche Akademie der Wissenschaften, Institut für angewandte Mathematik und Mechanik, Berlin, East Germany). (*Conférence Nationale de Mécanique Appliquée, Bucharest, Rumania, June 23-27, 1969.*) *Revue Roumaine des Sciences Techniques, Série de Mécanique Appliquée*, vol. 16, no. 1, 1971, p. 57-80. 10 refs. In German.

Investigation of the turbulent flow in the initial section of a convergent axisymmetric nozzle on the basis of the logarithmic velocity law. The velocity is regarded as constant in the inlet cross section, while in the middle of the nozzle potential flow is assumed. The friction layer on the nozzle wall is regarded as turbulent from the inlet cross section on. In the inlet region the wall shear stress, the boundary layer thickness, and the potential flow velocity in the middle of the nozzle, which figure in the logarithmic law, are unknown functions of the path length, which must be determined with the aid of the continuity and momentum integral theorem, and with the aid of the condition of steady connection of the velocity at the edge of the boundary layer to the velocity of the potential flow in the middle of the nozzle. The mathematical formulation leads to an ordinary first-order initial value problem, the distinguishing feature of which lies in the fact that explicitly given functions do not appear on the right-hand side of the differential equation; these functions can be determined only during the course of the calculations, partly from series expansions, and partly from a transcendental resolvent equation. A.B.K.

**A71-22470 Unloading the ATC system.** Glen A. Gilbert (Glen A. Gilbert and Associates). *CATCA Journal*, Fall 1970, p. 13-19.

Analysis of ATC system capability problems which points to certain deficiencies which cause inefficiency in airport and airspace utilization. The system elements contributing to these deficiencies basically involve airports, the air vehicles, procedures, air/ground equipment, and the controller-pilot human element. Major attention is given to area navigation (RNAV). Three-dimensional RNAV can substantially reduce the likelihood of midair collisions. Incorporation of a fourth dimension (time) further enhances the applicability of

3-D RNAV. Advanced ATC applications and the traffic mix are discussed. F.R.L.

**A71-22582 Unsteady flow past a flat plate normal to the direction of motion.** Sadatoshi Taneda and Hiroyuki Honji (Kyushu University, Fukuoka, Japan). *Physical Society of Japan, Journal*, vol. 30, Jan. 1971, p. 262-272. 17 refs.

Experimental investigation, using flow-visualization techniques, of the development of the separated flow past a flat plate which was started from rest either impulsively or with uniform acceleration. The flow is irrotational initially, and the onset of separation takes place at the two edges of a plate. The symmetrical twin vortices are always formed at small times no matter how large the Reynolds number may be. The length of the wake bubble is nearly proportional to  $(U t/d)$  to the  $2/3$  power, or  $(a t^2/d)$  to the  $2/3$  power at small values of  $(\nu t/d^2)$ ,  $U$  being the plate speed,  $t$  the time from the start,  $d$  the plate length,  $a$  the acceleration, and  $\nu$  the kinematic viscosity. The length of the symmetrical wake bubble exceeds 4.1 plate lengths at  $a d^3/\nu^2 = 4200$ . F.R.L.

**A71-22592 The channel wing - An answer to the STOL problem.** E. F. Blick (Oklahoma, University, Norman, Okla.). *Shell Aviation News*, no. 392, 1971, p. 2-7.

Review of the possibilities of the channel wing aircraft as a means of reducing the direct operating costs of power-augmented lift STOL aircraft. The present Custer Channel Wing Aircraft, which has five seats and a maximum gross weight of 5000 lb, and is powered by two hp Continental engines, is described. The aerodynamic theory of the channel wing is outlined; it takes advantage of the Bernoulli principle. The main advantage the channel wing concept has over other power-augmented lift STOL concepts is its simplicity. It can be built with less moving parts than a CTOL aircraft because it does not require flaps; only the additional channel structure is needed, and this is not movable. F.R.L.

**A71-22595 Vibration strain on aircraft engine hooped turbine blades.** L. N. Rzhavin, N. I. Opalikhin, and V. V. Matveev (Akademii Nauk Ukrainskoi SSR, Institut Problem Prochnosti, Kiev, Ukrainian SSR). (*Problemy Prochnosti*, vol. 2, Feb. 1970, p. 3-7.) *Strength of Materials*, Feb. 1970, p. 107-111. Translation.

Results of an experimental study of the vibration stress of a new type of construction of shrouded aircraft engine turbine blades, using various methods of joining the shrouds. On the basis of a tensometric analysis of these blades on a working engine, it is found that setting up paired blades with a fixed tension along the shrouds ensures minimum vibration stress on the blades during vibrations in the first flexural mode under all conditions of operation of the engine. A.B.K.

**A71-22610 Digital ICs + VOR = simpler navigation.** Ivars Breikss (Honeywell, Inc., Denver, Colo.). *Electronics*, vol. 44, Mar. 15, 1971, p. 80-84.

A new converter-indicator for the VOR navigation system which uses ICs almost exclusively is considered. This design, in which the standard d'Arsonval meter indicator is replaced by a direct numeric readout using light-emitting diodes, is smaller and lighter than conventional types, consumes less power, and offers about a tenfold improvement in reliability. Further, it can be produced and sold for less than the least costly standard system. The advantages of the new system for a pilot in navigating from one point to another are discussed. Design and operational details of the new device are considered giving attention to the timing diagram. G.R.

**A71-22633 Some problems of the strength and durability of turboprop engines of high reliability.** V. I. Omel'chenko. (*Problemy Prochnosti*, vol. 2, Mar. 1970, p. 68-74.) *Strength of Materials*, Mar. 1970, p. 275-280. Translation.

Discussion of certain problems concerning deficiencies in the performance of turboprop engines and possible extension of their service life. For eliminating these deficiencies, special programs of accelerated tests are necessary. A method is proposed for determining a multivariable regressive relation between the failure rate and the rigidity of usage regimes. On this basis, a common program of accelerated aviation tests can be established. Z.W.

**A71-22652 #** Determination of the basic dimensions of a multielement mechanism with drive angles least deflecting from ninety degrees (Opredelenie osnovnykh razmerov mnogozvennogo mekhanizma s uglami peredachi, naimenee otkloniaushchimisya ot devyanosta gradusov). V. O. Fokin. *Mashinostroenie*, no. 1, 1971, p. 87-91. In Russian.

Design of a multielement flap mechanism taking into consideration three positions of its three working sections. It is found that in spite of the implementation of the given motion law, the mechanism obtained possesses drive angles which deflect least from 90 deg over the entire deflection range of the working sections. Z.W.

**A71-22678** Determination of atmospheric parameters in the transition range at altitudes 80-120 km. E. N. Golubev, V. V. Mikhnevich, and Iu. M. Trishina. (*Kosmicheskie Issledovaniia*, vol. 8, May-June 1970, p. 467-470.) *Cosmic Research*, vol. 8, May-June 1970, p. 431-434. 6 refs. Translation.

Discussion of a procedure for calculating the parameters of an unperturbed atmosphere from measurements performed at the surface of a bluntbody moving at hypersonic speeds under various aerodynamic conditions (from continuous to free-molecular flow). The procedure was developed on the basis of experimental data obtained with a geophysical rocket, aimed at determining the conditions occurring at the surface of the body (which must be known in order to determine the atmospheric parameters). The influence on the flow conditions of such factors as the configuration and velocity of the body, the flight altitude, and stagnation temperature was determined in wind-tunnel experiments. Corrections for the influence of changes in the Reynolds number on the flow conditions were computed on the basis of the Navier-Stokes equations. V.P.

**A71-22717** Test instrumentation for an F-111 static test airframe. Donald K. Neff (General Dynamics Corp., Convair Div., San Diego, Calif.). In: Instrument Society of America, Annual Conference, 25th, Philadelphia, Pa., October 26-29, 1970, Proceedings. Part 2. Pittsburgh, Instrument Society of America (Advances in Instrumentation. Volume 25. Part 2), 1970, p. 625.1-625.6.

The primary purposes of test instrumentation on the F-111 static test airframe are to monitor test load parameters and to measure certain parameters of structural behavior. The application of electronic computers for data acquisition and data processing facilitates simultaneous use of a large number of measurement transducers. Four hundred data channels of strain, load, and deflection are scanned and recorded on magnetic tape within one second. Some of these test data are also visually displayed and recorded on X-Y plotters, and immediate printout in numerical engineering units is available by playback of the magnetic tape through a processor located in the data station. The strain gages recorded for each specified test condition are selected from approximately 2500 installations on the aircraft. A Land-line network connects transducers from the three component testing areas to 800 signal conditioners in the data station. (Author)

**A71-22719** High temperature dynamic strain gage evaluation system. John M. Hudson (General Electric Co., Cincinnati, Ohio). In: Instrument Society of America, Annual Conference, 25th,

Philadelphia, Pa., October 26-29, 1970, Proceedings. Part 2.

Pittsburgh, Instrument Society of America (Advances in Instrumentation. Volume 25. Part 2), 1970, p. 628.1-628.8.

A test program was initiated to define the high temperature dynamic precision, life, and environmental limitations of Karma strain gages installed with flame sprayed alumina. The gages are to be used in connection with gas turbine design and development which requires strain measurement at temperatures up to 1800 F. Design requirements are examined. A deflection controlled system is used in order to obtain the necessary accuracy. Test beam configuration, loading system, and heating system are described. It is pointed out that a computer program is available for calculating the interaction of temperature, strain, and deflection. The measurements conducted are discussed taking into consideration an accuracy analysis. G.R.

**A71-22725** Strain level counter for monitoring aircraft fatigue. David E. Weiss (U.S. Naval Material Command, Naval Air Development Center, Warminster, Pa.). In: Instrument Society of America, Annual Conference, 25th, Philadelphia, Pa., October 26-29, 1970, Proceedings. Part 2. Pittsburgh, Instrument Society of America (Advances in Instrumentation. Volume 25. Part 2), 1970, p. 646.1-646.4.

This paper describes the specifications, development and construction of a Strain Level Counter which presents counts of the number of times that each of four strain levels has been exceeded. The system has two major components: (1) a strain sensor, mounted in the critical structural area, which develops a voltage proportional to the strain; and (2) an indicator unit which houses all the solid state circuitry necessary to energize the sensor and condition its output. The output, after appropriate filtering, is displayed visually on four electro-mechanical counters. Overall accuracy is estimated to be within 5%. Laboratory tests have been completed; flight tests are planned. Based on the laboratory tests, the system is completely developed for use in such obvious applications as monitoring strains in bridges, towers, and other ground-based structures and vehicles. Flight testing will be necessary for qualification for use in aircraft. (Author)

**A71-22726** Remote test site computation of complex engine inlet dynamic parameters using an analog computer. E. L. Smith and P. M. Fleetwood (McDonnell Aircraft Co., St. Louis, Mo.). In: Instrument Society of America, Annual Conference, 25th, Philadelphia, Pa., October 26-29, 1970, Proceedings. Part 2.

Pittsburgh, Instrument Society of America (Advances in Instrumentation. Volume 25. Part 2), 1970, p. 647.1-647.9.

A system to provide real time computation and display of complex engine inlet distortion parameters which are computed from a large number of dynamic pressure data signals, was successfully implemented, using integrated circuit operational amplifiers as the primary analog computational elements. Pratt and Whitney engine parameters in use at the time are shown and hardware diagrams of the computational circuitry are explained. It is shown how the system provided flagging pulses to the raw data tapes for subsequent digitization and computer analysis of 'worst case' data, with resultant improvement in test data at significant savings in time and money. (Author)

**A71-22727 \*** The design, construction, and operation of Purdue University's new Combustion Research Laboratory. C. M. Ehresman (Purdue University, Lafayette, Ind.). In: Instrument Society of America, Annual Conference, 25th, Philadelphia, Pa., October 26-29, 1970, Proceedings. Part 2. Pittsburgh, Instrument Society of America (Advances in Instrumentation. Volume 25. Part 2), 1970, p. 648.1-648.12. Grant No. NSG(f)-21.

This building complex consists of a Test Cell Building, a Control Building housing the laboratory control and data acquisition system

and an instrumentation service area, and Propellant Storage Buildings. The instrumentation system is designed to provide the wide range of capability needed to support the fundamental research objectives required of this laboratory. The data acquisition system consists of three basic elements: a 40-channel digital data system having a taped output compatible with the IBM 7094 or the CDC 6500 computers available at the university's Computer Science Center, a 14-channel analog tape system with provisions for tape playback to the oscillograph or the digital data system; and, for direct analog data readout, a 36-channel oscillograph and nine high-speed strip chart recorders. Data-system calibration techniques are designed for propulsion-oriented experiments. M.M.

**A71-22728 # Application of total-head and flow-rate adapters for determining the density and velocity of a rarefied gas flow (Ispol'zovanie nasadka polnogo napora i raskhodnogo nasadka dlia opredeleniia plotnosti i skorosti potoka razrezhennogo gaza).** M. V. Prochukhaev. *Inzhenerno-Fizicheskii Zhurnal*, vol. 19, Dec. 1970, p. 998-1001. 5 refs. In Russian.

Experimental investigation of the density and velocity of a rarefied gas flow within the range of freestream Mach numbers from 3.1 to 9.0 and freestream Reynolds numbers from 45 to 1500. The results obtained are tabulated and discussed. In addition, experimentally determined transverse density and velocity profiles within the isentropic flow core region are presented. O.H.

**A71-22768 Static pressure measurement.** Marshall H. Brenner (Boeing Co., Seattle, Wash.). In: Instrument Society of America, International Aerospace Instrumentation Symposium, 16th, Seattle, Wash., May 11-13, 1970, Tutorial Proceedings. Edited by J. D. Chalupnik, J. E. Jorgensen, and B. Washburn. Pittsburgh, Instrument Society of America (Fundamentals of Aerospace Instrumentation. Volume 3), 1970, p. 1-16.

It is the objective of the included series of tables and graphs to provide the instrument user with pertinent performance information on select pressure instruments. The select pressure instruments are those generally applicable to aircraft instrumentation and calibration requirements, the more accurate instruments (for calibration and on-line use) and for the most part represent the latest generation of 'old principle' instruments. (Author)

**A71-22770 Altitude rate generation.** Merlin H. Wiese (Boeing Co., Renton, Wash.). In: Instrument Society of America, International Aerospace Instrumentation Symposium, 16th, Seattle, Wash., May 11-13, 1970, Tutorial Proceedings. Edited by J. D. Chalupnik, J. E. Jorgensen, and B. Washburn. Pittsburgh, Instrument Society of America (Fundamentals of Aerospace Instrumentation. Volume 3), 1970, p. 24-30.

Altitude rate generation as distinguished from linear pressure rate is required in the aerospace industry for functional test of various aircraft instruments, including Rate-of-Climb Indicators, Rate-of-Climb Switches and Central Air Data Computers. Several methods of generating altitude rates have been tried but, in general, are unsatisfactory due to basic inaccuracies. A new system consisting of a Hawker Siddeley Dynamics automatic test station, combined with two Schwien manometers has been developed for use at The Boeing Company, Renton. This system meets the altitude rate generation requirements of 100 ft/min to 30,000 ft/min, with an accuracy of plus or minus 1%. (Author)

**A71-22779 \* # Nuclear power for surface effect vehicle and aircraft propulsion.** Frank E. Rom (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Annual Meeting, 7th, Houston, Tex., Oct. 19-22, 1970, Paper 70-1221*. 22 p. 8 refs.

Preliminary results of an economic study that indicates the potential application of nuclear surface effect vehicles and aircraft for carrying transoceanic commerce in the post 1980 time period are presented. A summary of recent encouraging mobile nuclear reactor safety experiments for high speed impacts is also presented. The results of the economic study indicate that there would be a potential need for about 1500 nuclear surface effect vehicles of 10,000 tons gross weight with a speed of 100 knots to handle transoceanic commerce if the shipping cost would be about 1 to 2 cents per ton mile. The study indicates that nuclear powered surface effect vehicles may have the ability to carry cargo at rates less than 2 cents per ton mile. Subsonic nuclear aircraft with a gross weight of 1000 tons may be able to carry cargo at the rate of 4 to 5 cents per ton mile. Very large subsonic nuclear aircraft of the order of 10,000 tons in gross weight may be able to carry cargo at rates less than 2 cents per ton mile. It would take a fleet of 500 such aircraft to handle transoceanic trade that would be economically feasible to carry at 1 to 2 cents per ton mile in 1980. (Author)

**A71-22788 Conversion of large schlieren systems to holographic visualization systems.** J. D. Trolinger (ARO, Inc., Arnold Air Force Station, Tenn.), W. M. Farmer, and R. A. Belz (Tennessee, University, Tullahoma, Tenn.). In: Instrument Society of America, International Aerospace Instrumentation Symposium, 15th, Las Vegas, Nev., May 5-7, 1969, Tutorial Proceedings.

Edited by B. Washburn. Pittsburgh, Instrument Society of America (Fundamentals of Aerospace Instrumentation. Volume 2), 1969, p. 89-96. 11 refs.

Results of an experimental and theoretical study in the application of holographic visualization in operational wind tunnels and test facilities are discussed. The study revealed that optical requirements for image holography were similar to those for conventional schlieren and further, that a natural conversion from conventional schlieren to holographic visualization exists. A twenty-inch diameter, single pass, schlieren system was converted for holographic visualization and applied successfully to wind tunnel studies. With this system, holograms are produced which are used to provide three-dimensional photography, variable focus shadowgraph, variable knife edge schlieren, and variable fringe interferometry, all from a single photographic plate. The problems encountered in the conversion are discussed, and examples of the data output are shown. (Author)

**A71-22799 # Stability of a rotor in polycentric bearings with gas lubrication (K voprosu ob ustoiichivosti rotora v mnogo-tsentrovnykh podshipnikakh s gazovoi smazkoi).** V. N. Drozdovich (Leningradskii Institut Tochnoi Mekhaniki i Optiki, Leningrad, USSR). *Priborostroenie*, vol. 13, no. 11, 1970, p. 98-101. In Russian.

Theoretical study of the stability of an unloaded pin in a radial bearing with an arbitrary periodic profile. The purpose of the study is to determine the effect of the geometry of the carrying surface of a radial gas-dynamical bearing on the stability of the central position of a rotor in a dynamic equilibrium without a radial load. Complex equations of small forward oscillations of a pin are derived from an equation describing a linearized gas lubrication model. The equations are used in an analysis of the oscillations of a pin about a central position in a state of dynamic equilibrium. Conditions of asymptotic stability are determined for this pin. V.Z.

**A71-22811 \* # Concepts for cost reduction on turbine engines for general aviation.** Robert L. Cummings and Harold Gold (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Manufacturing Engineers and American Society for Nondestructive Testing, Western Metal and Tool Exposition Conference, Los Angeles, Calif., Mar. 8-11, 1971, Paper*. 22 p.

Preliminary results of gas-turbine engine design and fabrication studies conducted to evaluate possible engine-cost reductions for general aviation aircraft. Topics considered include (1) engine cycle

analyses and aircraft performance studies relating to cost-performance tradeoffs, (2) proposed engine configurations, (3) a fabrication development program intended to establish new compressor and turbine construction methods, (4) production of experimental models, (5) a new hydromechanical fuel control system, and (6) the development of low-cost accessories. T.M.

**A71-22851**      **Stability of a stratified free shear layer.** S. A. Maslowe and J. M. Thompson (Lockheed-California Co., Burbank, Calif.). *Physics of Fluids*, vol. 14, Mar. 1971, p. 453-458. 10 refs.

The stability of the laminar mixing region between two uniform streams is investigated by numerically solving the linear sixth-order equation for the disturbance amplitude function. This equation includes the effects of both viscosity and heat-conduction and is, therefore, regular at the critical point, where the mean flow velocity and disturbance phase speed are equal. Both the neutral stability curve and curves of constant amplification rate are computed for various Richardson numbers. The results show that the damping effects of diffusion are quite small and, therefore, that the Richardson number is the dominant parameter governing the stability of the flow. Streamlines are computed for neutral disturbances and it is found that, in the inviscid limit for long waves, the flow pattern approaches the configuration obtained previously by Taylor in his study of a discontinuous three-layer model. (Author)

**A71-22858 \* #**      **Propagation of sonic booms and other weak nonlinear waves through turbulence.** A. R. George and Kenneth J. Plotkin (Cornell University, Ithaca, N.Y.). *Physics of Fluids*, vol. 14, Mar. 1971, p. 548-554. 20 refs. Grant No. NGR-33-010-054.

The structure of weak shocks propagating over long distances through turbulence modeled by sound speed fluctuations is investigated. The equilibrium wave shape is governed by a balance between nonlinear steepening and a dissipative mechanism due to acoustic scattering of high-frequency energy out of the incident wave direction. This scattered energy appears as perturbations arriving behind the shock. For conditions representative of sonic boom and explosion wave propagation over long distances the mean wave structure is governed by a Burgers' equation similar to that describing viscous shocks, the difference being that parameters describing the turbulent scattering appear in the dissipative term. The theoretical predictions agree in order of magnitude with experiments on atmospheric propagation of sonic boom and explosion waves.

(Author)

**A71-22889**      **The effects of metallic coatings on the fatigue properties of high strength steels.** Edward J. Jankowsky, Joseph Viglione, and Sara J. Ketcham (U.S. Naval Material Command, Naval Air Development Center, Warminster, Pa.). *National Association of Corrosion Engineers, National Meeting, Chicago, Ill., Mar. 22-26, 1971, Paper 23*. 15 p. 8 refs.

Summary of work done in this area, with presentation of comparative quantitative data which can be used as design criteria. The effect of chromium plating on the fatigue properties of high strength 4340 steel, shot peening effects on the fatigue properties of chromium plated high strength steels for use at temperatures up to 1000 F, and the effects of plasma sprayed coatings, electroless nickel and aluminum coatings on steels are described. F.R.L.

**A71-22890 #**      **Hawker Siddeley Trident 3B. Aircraft Engineering**, vol. 43, Feb. 1971, p. 6-8, 10-16 (8 ff.).

The Trident 3B is the fourth member of the Trident family and the third to enter service with B.E.A., who have ordered twenty-six of the new aircraft. The flight test program conducted is discussed. The investigation included a test of the performance of the aircraft in conditions of high temperature and high humidity. It is pointed out

that the Trident 3B is the first airliner to incorporate a booster engine as an integral part of the design. Aspects of the installation and the operation of the booster engine are discussed. G.R.

**A71-22891**      **The responsibility of air traffic controllers - Disciplinary procedure (La responsabilité des contrôleurs de la navigation aérienne - Procédure disciplinaire).** R.-A. Loosli. *Revue Générale de l'Air et de l'Espace*, vol. 33, no. 4, 1970, p. 376-390. 47 refs. In French.

Study of the legal responsibility which might devolve on flying control services, and its limits. The problem resides in the nature of the relationships between operating personnel in the aircraft and the flying control personnel. The sanctions which apply to aircrew are briefly discussed. Air traffic controllers are responsible for clearances and instructions to aircrew, and authorization of flight under IFR, IMC, and VMC. Legislation in France and the U.S. is compared. Legal aspects of several midair collisions are discussed. Some comments are made on problems of responsibility arising when air traffic control is functioning. F.R.L.

**A71-22915 \* #**      **Snatch force during lines-first parachute deployments.** Earle K. Huckins, III (NASA, Langley Research Center, Space Technology Div., Hampton, Va.). (*American Institute of Aeronautics and Astronautics, Aerodynamic Deceleration Systems Conference, Dayton, Ohio, Sept. 14-16, 1970, Paper 70-1171*.) *Journal of Spacecraft and Rockets*, vol. 8, Mar. 1971, p. 298, 299. 5 refs.

Snatch force, for a lines-first type of deployment, is shown to be a result of the large increase in the linear mass density of the unfurling decelerator as the canopy skirt emerges from the deployment bag. An expression which approximates the snatch force is derived by means of a steady-state analysis which considers the wave propagation characteristics of the suspension lines. Results obtained by using the new technique showed significantly better correlation with flight data than results obtained by using the 'handbook method' which is based on the deployment process characteristic of a canopy-first type of deployment. (Author)

**A71-22941**      **Heat transfer to slender bodies at a Mach number of 5.2.** R. K. Fancett (Royal Armament Research and Development Establishment, Fort Halstead, Kent, England). *Aeronautical Quarterly*, vol. 22, Feb. 1971, p. 12-24. 6 refs.

Because of the lack of reliable data on heat transfer to long bodies, measurements have been made to cone-cylinder-flares at a Mach number of 5.2. Axial heat transfer distributions were closely predicted by a modified reference enthalpy method for both laminar and turbulent flows at zero incidence and the heat transfer to the flare windward generator at incidence agreed with laminar theory. (Author)

**A71-22942**      **On the flutter of a smooth circular cylinder in a wake.** Alan Simpson (Bristol, University, Bristol, England). *Aeronautical Quarterly*, vol. 22, Feb. 1971, p. 25-41. 5 refs.

The stability of a smooth circular cylinder, free to translate horizontally and vertically against linear springs in the wake from an identical neighbouring cylinder, is studied using quasi-static aerodynamic derivatives and simple flutter theory. It is found that at spacing values between ten and twenty cylinder diameters (typical of the spacing employed on 'bundled' overhead transmission lines) classical flutter of the leeward cylinder can occur in a certain critical range of wind speeds at certain orientations of this cylinder in the wake. However, the occurrence of flutter appears to be conditional on a positive difference of natural frequency between vertical and horizontal motions of the leeward cylinder in still air. Classical static instability (divergence) of the leeward cylinder is also shown to be possible over the entire 'incidence' range in the wake, but this occurs in a much higher wind speed range than that associated with flutter. (Author)

**A71-22943**      **The interaction of the wake from an oscillating blade with a fixed cascade.** D. S. Whitehead and V. G. Nabar (Cambridge University, Cambridge, England). *Aeronautical Quarterly*, vol. 22, Feb. 1971, p. 42-52. 6 refs. Research supported by the Ministry of Technology.

The paper presents a theoretical investigation of the flow when the wake from a single vibrating aerofoil interacts with a fixed downstream cascade set normal to the mean flow direction. It is concluded that the effects of the cascade extend upstream by a distance of about one quarter of the wavelength of the fluctuations in the wake. It is also found that the wake passes through the cascade unchanged in strength, but that the cascade sheds vorticity of equal and opposite magnitude, so that, if an average is taken in the direction parallel to the cascade, the wake is annulled. (Author)

**A71-22944**      **Secondary mass injection in a hypersonic flow.** P. G. Simpkins (Bell Telephone Laboratories, Inc., Murray Hill, N.J.). *Aeronautical Quarterly*, vol. 22, Feb. 1971, p. 53-64. 21 refs.

This paper describes an experimental study of the interaction between a hypersonic flow and a transverse jet which issues radially from a slender conical model. Measurements in the region far upstream of the jet show qualitative agreement with free interaction analyses, while downstream a film cooling effect appears to reduce the heat transfer rate substantially. The effect of changes in Reynolds number, jet pressure ratio and mass flux is examined and compared with similar phenomena caused by fixed disturbances such as compression corners. The shape of the interaction shock wave is found to agree with the predictions of the second-order blast wave theory. Finally a correlation is found between the boundary layer separation length and a local mass flux parameter. (Author)

**A71-22945**      **The estimation of pressure on finite symmetrical wings in subsonic flow.** R. H. Eldridge and F. Walkden (Salford, University, Salford, Lancs., England). *Aeronautical Quarterly*, vol. 22, Feb. 1971, p. 65-82. 13 refs.

Description of a numerical method for estimating the pressure distribution on arbitrary finite symmetrical wings with rounded leading edges at zero incidence in subsonic flow. The subsonic flow equations are linearized so that the value of the partial derivative with respect to  $\phi$  over the partial derivative with respect to  $x$  at a point on the wing mean plane can be expressed as the generalized principal part of a singular double integral. This integral is modified so that it can be evaluated numerically. Finally  $C_{sub p}$  is obtained from the partial derivative with respect to  $\phi$  over the partial derivative with respect to  $x$  by using the approximation  $C_{sub p} = -2$  times the partial derivative with respect to  $\phi$  over the partial derivative with respect to  $x$ . Two numerical methods are described; one method to be used when the field point is close to the leading edge and the other for field points in other regions. Numerical results for two wings (Warren 12 and NPL 55 deg swept) are given and, wherever possible, the computed results are compared with results from other methods and with experiment. (Author)

**A71-22946**      **A lifting-surface theory for the rectangular wing in nonstationary flow.** J. M. R. Graham (Cambridge University, Cambridge, England). *Aeronautical Quarterly*, vol. 22, Feb. 1971, p. 83-100. 9 refs.

A method of obtaining the load distribution on thin rectangular wings in nonstationary incompressible flow is presented, with particular reference to the problem of gust-induced loading. The method utilizes solutions to a Fourier transform of the downwash integral equation, enabling the problem to be expressed in the form of a set of dual integral equations having a series solution. Some values of the overall lift coefficient are computed and compared with values of lift coefficient obtained by collocation methods. The method is easily extendable to subsonic compressible flows. (Author)

**A71-22947 #**      **Control system of the Soviet D-30 bypass engine (Układ sterowania radzieckiego silnika dwuprzepływowego**

**D-30).** Emil Wegrzyn. *Technika Lotnicza i Astronautyczna*, vol. 25, Oct.-Nov. 1970, p. 7-10. In Polish.

Description of the electrical, mechanical, and hydraulic control system components for the Soviet D-30 bypass engine used in the Tu-134 aircraft. The N-30 fuel flow control assembly is explained in terms of operation under steady, acceleration, and starting conditions. The CR-1W centrifugal governor assembly regulates the low-pressure compressor speed, while the CR-2W centrifugal governor assembly controls air supply and bleed vents, with an additional function of regulating the inlet guide vanes of the high-pressure compressor. T.M.

**A71-22948 #**      **Snow removal and deicing of transport aircraft (Odladzanie i odśnieżanie samolotów transportowych).** Jan Wyganowski. *Technika Lotnicza i Astronautyczna*, vol. 25, Oct.-Nov. 1970, p. 28-33. In Polish.

Description of antifreeze liquids and sprayer equipment used by the Polish Airlines LOT for deicing aircraft on the ground. A nonflammable, nontoxic antifreeze liquid (designated KMW-O) was developed for spraying on the iced aircraft surfaces. The liquid is heated to 95 deg C and sprayed from specially constructed trucks having retractable towers. Prior to deicing, snow is removed mechanically by brushes. T.M.

**A71-22949 #**      **Airports on the sea (Lotniska na morzu).** Eligiusz Kołodziński. *Technika Lotnicza i Astronautyczna*, vol. 25, Oct.-Nov. 1970, p. 34, 35. In Polish.

Discussion of the structural design and financial aspects of a floating airport (seadrome) previously proposed by Harris (1970). The basic runway elements consist of hollow concrete blocks filled with polystyrene foam and joined with cables. The runways are surrounded with breakwaters formed by floating flat slabs on which the waves break and lose energy as on a beach. This type of breakwater does not require very strong anchorage. T.M.

**A71-22950 #**      **Radar simulators and their use in training air traffic controllers (Symulatory radiolokacyjne i ich zastosowanie w szkoleniu kontrolerów ruchu lotniczego).** Waldemar Barski. *Technika Lotnicza i Astronautyczna*, vol. 25, Oct.-Nov. 1970, p. 36-41. In Polish.

Description of optical and electronic equipment used for training air traffic controllers in the use of surveillance and approach radars at terminal control areas. Emphasis is placed on the design and operation of a new analog simulator developed by Solartron and currently used at Warsaw's Okęcie airport. T.M.

**A71-22951 #**      **Progress in safety with industry.** Paul Holden (GPS Sciences, Ltd., England). *Aircraft Engineering*, vol. 43, Jan. 1971, p. 6-8, 12.

Development of the proposition that the best contribution that ATC can make to the overall safety of air traffic systems is by reducing the routine, semiroutine, and distracting tasks that do nothing to assist the controller in performing his task of strategic or tactical controlling of aircraft. This means exploiting within the immediate future some or all of these techniques and equipment: flight data and radar data processing, computer drive and labeled display, data link communications, satellites for communication and navigation surveillance, computer-assisted approach sequencing, conflict prediction systems, conflict resolution, high accuracy multitask and profile navigation, and data link command and access to the aircraft autopilot. F.R.L.

**A71-22952 #**      **Training and operations of air traffic control services.** T. Wilson (International Aeradio, Ltd., Southall, Middx., England). *Aircraft Engineering*, vol. 43, Jan. 1971, p. 10-12.

Review of some methods of training air traffic controllers developed and adopted by International Aeradio Ltd. (IAL), which has trained over 1000 students of 45 nationalities. The realism of radar simulation is greatly enhanced by providing the students with the same equipment that is used in the live environment, so that consoles with radio telephony controls, clocks, flight progress strips, wind indicators, and telephone liaison lines are all provided. Various types of operations carried out by IAL are described. F.R.L.

**A71-22953 # Recent developments in ATC systems.** C. W. Choules (Plessey Radar, Ltd., Weybridge, Surrey, England). *Aircraft Engineering*, vol. 43, Jan. 1971, p. 14-16.

Outline of some of the developments in the field of electronics which are being channeled toward further improvements in air safety. Automation in air traffic control, secondary surveillance radar, and the U.K. Mediator system are discussed. An air traffic control center for the control of all aircraft operating in the upper air space regions of Amsterdam, Brussels, Hanover, Frankfurt, and Stuttgart, which is scheduled to come into operation by 1973, is described. F.R.L.

**A71-22954 # The value and purpose of digital ATC simulation.** R. N. Harrison (Ferranti, Ltd., Hollinwood, Lancs., England). *Aircraft Engineering*, vol. 43, Jan. 1971, p. 18, 19, 28.

Description of the place of the digital simulator in the training of air traffic control officers. Factors involved in digital simulation fall into three categories: traffic authenticity, realism of the working environment, and the need to acquire familiarity with the geographical environment. The concepts of the simulator are exercise capability and planning, aircraft control positions, the blip driver, programming, data, strip printing, and expansion capability. F.R.L.

**A71-22955 # Secondary surveillance radar in ATC systems.** R. Shipley (Cossor Electronics, Ltd., Harlow, Essex, England). *Aircraft Engineering*, vol. 43, Jan. 1971, p. 20, 21.

Description of the advantages and implications to the controller of the introduction of secondary surveillance radar (SSR) facilities. The advantages of SSR are increased range for lower transmitted power, no clutter from weather or permanent echoes on the PPI, positive identification without aircraft maneuvers, reduction of R/T messages for identification, and air-to-ground information link. Continuing increase in air traffic density has led to the use of computers at the major centers to relieve the strain on controllers. F.R.L.

**A71-22956 # Test facility for high thrust aero engines.** W. J. Pitt (John Curran, Ltd., Cardiff, Wales). *Aircraft Engineering*, vol. 43, Jan. 1971, p. 26, 28.

Description of a new test bench suitable for advanced technology engines of up to 100,000 lb thrust. An integrated design was developed in which the moving frame of the test bench, to which the thrust is imparted, is suspended on flexural strips from load-spreading beam assemblies at each end of the bench. The result is an economical design, particularly considering the high thrust capacity of the test bench. It also avoids the use of sophisticated materials, thus ensuring that the fabrication can be achieved with the ordinary range of machine tools. F.R.L.

**A71-22957 # The NAE high Reynolds number 15 in. x 60 in. two-dimensional test facility - Description, operating experiences and some representative results.** L. H. Ohman and D. Brown (National Research Council, Ottawa, Canada). *American Institute of Aeronautics and Astronautics, Aerodynamic Testing Conference, 6th, Albuquerque, N. Mex., Mar. 10-12, 1971, Paper 71-293*. 26 p. 6 refs. Members, \$1.50; nonmembers, \$2.00.

This new facility consists of a 15 in. wide and 60 in. high two-dimensional test section that mounts in the transonic test section of the NAE 5 x 5 ft blowdown wind tunnel. The geometric characteristics are outlined and associated systems consisting of sidewall boundary layer control, sidewall balances and wake traverse mechanism are described in fair detail. Various problems encountered during the operation of the facility are discussed together with proposed as well as applied remedies. Some typical results obtained with models of a NACA 64 series airfoil section are presented, demonstrating the effect of sidewall boundary layer control as well as wall interference on the measured aerodynamic characteristics. (Author)

**A71-22963 Development of gearing for aircraft (Entwicklung von Getrieben für Luftfahrzeuge).** Reinhard Rieger and Gisbert Lechner (Zahnradfabrik Friedrichshafen AG, Friedrichshafen, West Germany). *VDI-Z*, vol. 113, Feb. 1971, p. 127-136. 8 refs. In German.

The design and development of toothed wheel gearing for aircraft and, especially, for VTOL craft are surveyed. General considerations underlying the design of aircraft gear systems are reviewed. Helicopter gear systems in operation are described, with special attention to bearings, shaft connections, titanium alloy components, lubricants, and the overall lubrication system. Quality control and assurance procedures are also briefly discussed. M.V.E.

**A71-22964 Fan propulsion for commercial vertical-takeoff aircraft (Gebläseantriebe für Vertikalstart-Verkehrsflugzeuge).** Albrecht Hartmann (M.A.N. Maybach Mercedes-Benz, Munich, West Germany). *VDI-Z*, vol. 113, Feb. 1971, p. 137-141. In German.

Various energy distribution systems for thrust boosting in VTOL aircraft are discussed. The elements of fan propulsion power plants using mechanical and gas-dynamical energy distribution systems are reviewed. Alternative airframe-propulsion plant integration designs are compared and their relative merits examined. It is felt that at the present state of the art a fan driven by a rotor-blade-tip turbine may represent the most promising design principle for a first generation of lift thrustors with a high mass flow ratio. M.V.E.

**A71-22965 Problems of thermodynamics and gasdynamics (Problèmes de thermodynamique et de gazodynamique).** B. Kodja (Aleppo, University, Aleppo, Syria). Paris, Masson et Cie., Editeurs, 1971. 272 p. In French.

The principal purpose of this work is to put into the hands of students of engineering and science such material as will make it possible for them to familiarize themselves with practical applications of the theories and formulas of thermodynamics, and with the logic and reasoning employed in developing actual apparatus. Nearly 100 problems illustrating the applications of postulates and principles to compressors, combustion, piston internal combustion engines, steam and gas turbines, turbojets, refrigeration machinery, and heat pumps are presented. The different chapters are independent of each other, thus facilitating their use in any order. Tables and Mollier diagrams are given in appendices. F.R.L.

**A71-22989 Compensation for death and injury in international air transport - A European view.** F. E. Mostyn and P. Martin. *Aeronautical Journal*, vol. 75, Feb. 1971, p. 85-90; Discussion, p. 90-92. 12 refs.

Discussion of the problem of whether strict liability without fault and without limitation of damages should be imposed on carriers in case of death or injury in international commercial air transport or whether the idea of a limitation of compensation should be accepted. Conflicting views of two British solicitors on this subject are presented. O.H.

**A71-22990 Compensation for death and injury in international air transport - A United States view.** J. Kennelly and G. Lapham. *Aeronautical Journal*, vol. 75, Feb. 1971, p. 92-105.

Discussion of the extent of liability to be imposed on carriers in case of death or injury in international commercial air transport from the point of view of the legal system of the United States. Provisions of the proposed amendment to the Warsaw Convention which are believed to be incompatible with fundamental concepts of justice and equality, and violative of constitutional safeguards of the Constitution of the United States, are critically examined. Opinions of two American representatives are presented. O.H.

**A71-22996 Ultra high tensile steel landing gear components - Material selection and manufacture.** W. M. Imrie (Dowty Rotol, Ltd., Gloucester, Glos., England). *Aeronautical Journal*, vol. 75, Feb. 1971, p. 139-152. 8 refs.

Discussion of the characteristics of ultra high tensile steels and the technical advantages of specifying these steels for landing gears and other critical applications in aircraft design. The composition and mechanical properties of some available ultra high tensile steels are presented and quality requirements for their supplies are considered. The manufacture and testing of the DC-10 noise landing gear using these steels is discussed in detail. O.H.

**A71-23000 On the question of the applicability of the air traffic law to space law (Zur Frage weltraumrechtlicher Anwendbarkeit des Luftverkehrsgesetzes).** Günter B. Krause. *Zeitschrift für Luftrecht und Weltraumrechtsfragen*, vol. 20, Jan. 15, 1971, p. 1-9. 41 refs. In German.

It is pointed out that the vehicles and devices considered by the air traffic law also include spacecraft. Legally this inclusion of spacecraft implies that the regulations of the air traffic law are applicable to spacecraft. The validity of the regulations is limited, however, to the object of the law - i.e., to air traffic. The air traffic law is, therefore, in principle only applicable to the start and landing phases of spacecraft when they are passing through air space. There are, however, regulations of the air traffic law which apply indirectly to the flight in space outside the air space. Questions of jurisdiction regarding air traffic and traffic in space are examined. G.R.

**A71-23054 A reactive, equilibrium hypersonic flow over a slender pointed body.** Michiru Yasuhara and Toshio Kondo (Nagoya University, Nagoya, Japan). *Physical Society of Japan, Journal*, vol. 30, Feb. 1971, p. 563-566. Research supported by the Ministry of Education.

Study of a reactive equilibrium hypersonic gas flow over a slender body. The reaction considered is  $\text{nu}_{\text{sub } 1} \text{A} + \text{nu}_{\text{sub } 2} \text{B} = (\text{nu}_{\text{sub } 1} + \text{nu}_{\text{sub } 2})\text{C}$ , and it is assumed that the molecular weights and the specific heats at constant pressure of species 'A,' 'B,' and 'C' are the same, respectively. It is shown that approximate similarity solutions exist for power law bodies  $r_{\text{sub } b}$  approximately equal to  $x$  to the  $m$ th power. Numerical results for several values of  $m$  for two-dimensional bodies and bodies of revolution are presented for the reaction nitrogen + oxygen = 2 NO. F.R.L.

**A71-23057 # Vibration of a cylinder caused by wake force.** Masaya Funakawa and Ritsuro Umakoshi (Kawasaki Heavy Industries, Ltd., Kobe, Japan). *JSME, Bulletin*, vol. 14, Jan. 1971, p. 39-45; Discussion, p. 45, 46; Authors' Closure, p. 46, 47. 5 refs. Research supported by the Atomic Energy Bureau of Science and Technic Agency.

Experimental results on the vibration of a cylinder caused by shedding vortices undertaken at larger Reynolds number than in a previous experiment by the authors (1969). Two experiments are described, one being on an elastically supported cylinder, and the other on a crank-excited cylinder. In the former the exciting force

coefficient is determined from a decrement and an amplitude of the cylinder. In the latter, the exciting force coefficient is found by an integration of pressures on the cylinder surface. These two results coincide with each other; the exciting force suddenly decreases at nearly the critical Reynolds number. At subcritical Reynolds number a self-exciting force is induced just as previously determined by the authors, but at supercritical Reynolds number the exciting force decreases with an increasing cylinder amplitude, and at too large an amplitude the force is changed to a damping force. F.R.L.

**A71-23070 Meteorology for the supersonic transport (Meteorologie für den Überschall-Luftverkehr).** Heinz Panzram. *Naturwissenschaftliche Rundschau*, vol. 24, Mar. 1971, p. 113-115. In German.

It is pointed out that the operation of supersonic transport poses new meteorological problems because of the high altitude and the high flight velocities involved. Meteorological conditions for the subsonic flight phase at lower altitudes in connection with takeoff and landing operations are the same as for other aircraft. However, for the second flight phase during the transition from subsonic to supersonic velocities at altitudes between 9 and 16 km conditions are already dissimilar to those encountered by present airliners. The aid of Applications Technology Satellites and other satellites in providing better and more accurate information about thunderstorms which may occur even in the lower stratosphere is discussed. Problems regarding predictions concerning clear-air turbulence, wind, and temperature are examined. Other subjects considered are cosmic radiation, ozone, and supersonic boom. G.R.

**A71-23092 # Nonsteady three-dimensional stagnation-point flow.** E. H. W. Cheng, M. N. Özisik, and J. C. Williams, III (North Carolina State University, Raleigh, N.C.). *ASME, Transactions, Series E - Journal of Applied Mechanics*, vol. 38, Mar. 1971, p. 282-287. 7 refs.

The equations of motion for the three-dimensional nonsteady flow of incompressible viscous fluid in the vicinity of a forward stagnation point are reduced to three ordinary differential equations for a potential flow field chosen to vary inversely as a linear function of time. The resulting ordinary differential equations contain two parameters C and D; the former characterizes the type of curvature of the surface around the stagnation point and the latter the degree of acceleration or deceleration of the potential flow. The simple stagnation-point problems which have been studied previously are obtainable as special cases of the present analysis by assigning particular values to C and D. Exact solutions have been computed numerically for the velocity field and the pressure distribution in the boundary-layer flow around the stagnation point of a three-dimensional blunt body for the values of the parameter C from 0-1. (Author)

**A71-23162 # Foam polyurethanes and their use in flight vehicles (Penopoliuretany i ikh primeneniye na letatel'nykh apparatakh).** G. A. Bulatov. Moscow, Izdatel'stvo Mashinostroyeniye, 1970. 232 p. 70 refs. In Russian.

An attempt is made to analyze and systematize a number of features of the synthesis and application of foam polyurethanes. Specific examples of the use of foam polyurethanes in the construction of various flight vehicle assemblies (wings, controls, ailerons, rudder fin, stabilizer) as lightweight fillers and protective coatings are presented. It is shown that in a number of the cases cited an increase in the specific strength of the assembly in question is achieved, while in other cases not only is the thermal insulation improved but also such properties as fatigue strength, degree of leaktightness, and resistance to atmospheric factors. In addition to foam polyurethanes, the most significant features of other foam plastics used in aircraft structures are considered. A description is given of the equipment required for the synthesis and processing of foam plastics. A.B.K.

**A71-23173 # Dynamics of acceleration sensors with liquid damping** (K dinamike datchikov uskoreniy s zhidkostnym dempfirovaniem). V. A. Murashev and S. I. Makarikhin (Leningradskii Institut Aviatzionnogo Priborostroeniia, Leningrad, USSR). *Priborostroenie*, vol. 13, no. 12, 1970, p. 71-73. In Russian.

Study of the use of porous glass materials to ensure linear damping in liquid-damped accelerometers. The cause of damping nonlinearity is the onset of nonlaminar flow in the working channels of piston-type dampers. It is shown that liquid flow through porous materials retains its laminar nature, permitting near-linear damping over a wide range of velocity. Formulas are derived for the damping behavior as a function of the liquid properties and of the structure and thickness of the porous layer. T.M.

**A71-23199 # Fluid mechanics and aircraft design** (Sixth Nilakantan Memorial Lecture). D. Kuchemann (Royal Aircraft Establishment, Farnborough, Hants., England). *Aeronautical Society of India, Journal*, vol. 22, Aug. 1970, p. 141-156. 28 refs.

Selection and discussion of two specific ways in which fluid mechanics comes into aircraft design: the atmospheric environment in which an aircraft operates; and the types of flow which may occur on swept wings and have to be taken into account in their design. Major attention is given to aircraft intended to fly over short and medium ranges, possibly with STOL capability to suit the Indian environment. F.R.L.

**A71-23200 # A theory of thin airfoils in nonequilibrium magnetogasdynamics with nonequilibrium free stream.** Kul Deepak Nanda (Delhi, University, New Delhi, India). *Aeronautical Society of India, Journal*, vol. 22, Aug. 1970, p. 157-165. 5 refs.

The theory of thin airfoils in nonequilibrium magnetogasdynamics with nonuniform, nonequilibrium free stream is developed. A general result for the perturbation potential is obtained with the help of Green's functions technique. Two specific examples, namely, (1) a parallel nonequilibrium stream of constant velocity, and (2) a nonuniform, nonequilibrium stream, have been worked out. In particular, it is shown that in the supersonic, super-Alfvénic flows, the difference between the velocity potential of the flow at the surface of the body in a nonuniform, nonequilibrium free stream and the corresponding velocity potential in a uniform, equilibrium stream increases with the increase in the intensity of the magnetic field, while the reverse is the case in supersonic, sub-Alfvénic flows. (Author)

**A71-23201 # Optimisation of parameters for boundary layer control.** Jagdish Narain Mishra and Ashok Kumar Dhol (Birla Institute of Technology, Ranchi, India). *Aeronautical Society of India, Journal*, vol. 22, Aug. 1970, p. 166-171. 5 refs.

Boundary layer control is an important factor for energy transfer over aerofoils. It has further been observed that slot size, slot angle, slot positioning and flow quantity used for boundary layer control play a key role in energy transfer. In the present investigation an attempt has been made to optimize the slot angle, slot positioning and flow quantity affecting the boundary layer control. The variation of momentum loss thickness and changes in  $C_{sub} L$  with the position of suction and injection slots and flow quantity affecting the net change has also been studied. (Author)

**A71-23204 # Fatigue properties of aircraft materials at elevated temperatures.** S. Kumaran and E. G. Ramachandran (Indian Institute of Technology, Madras, India). *Aeronautical Society of India, Journal*, vol. 22, Aug. 1970, p. 189-193. 12 refs.

The effects of aerodynamic heating on fatigue and creep properties of aircraft materials have assumed great importance, with the advent of supersonic aircraft. In this paper is briefly discussed the importance of such study, with particular reference to the interaction between these deformation mechanisms. The available data on

the fatigue properties of some important aircraft alloys at elevated temperatures have been reviewed. In the case of the high duty R.R. 58 aluminum alloy, the fatigue strength remains practically unaffected between 20 and 175 C. In the case of titanium alloys the fatigue strength is reduced with increasing temperature, but the marked insensitivity of these alloys to notching is noteworthy. Finally the mechanisms of fatigue fracture at elevated temperature are discussed. The slip-zone microcracking which characterizes fatigue damage, produced by small strains at room temperature is progressively replaced by grain boundary cracking at elevated temperatures. In the case of precipitation hardened alloys, fatigue damage is initiated by persistent slip bands produced in regions of precipitate coarsening and overaging. (Author)

**A71-23273 American Society of Civil Engineers, Conference on Electronic Computation, 5th, Purdue University, Lafayette, Ind., August 31-September 2, 1970, Proceedings.** Conference co-sponsored by Purdue University. *American Society of Civil Engineers, Structural Division, Journal*, vol. 97, Jan. 1971. 509 p.

Included are a procedure for automated aircraft-wing structural design, a technique for interactive computer graphics in design, experience with Problem-Oriented Languages (POL) environment, an automatic generation of finite element matrices, efficient reanalysis of modified structures, formulation of decision logic tables, and computer-aided processing of design specifications. M.M.

**A71-23274 \* Procedure for automating aircraft wing structural design.** Gary L. Giles (NASA, Langley Research Center, Structures Research Div., Hampton, Va.). (*American Society of Civil Engineers, Conference on Electronic Computation, 5th, Purdue University, Lafayette, Ind., Aug. 31-Sept. 2, 1970.*) *American Society of Civil Engineers, Structural Division, Journal*, vol. 97, Jan. 1971, p. 99-113. 10 refs.

Description of a computer program entitled Design of Aircraft Wing Structures (DAWNS). Particular methods used to incorporate the analytical procedures required from the aerodynamic and structural disciplines into this automatic design program are described. Loads on the structure are calculated using linearized Mach box aerodynamics, and a finite element idealization is used for the structural analysis. During the design the structural members are fully stressed to the allowables of either material yield strength or buckling, or they are limited to minimum gauge. The program provides detailed design information such as aerodynamic pressure distribution, cross-sectional dimensions and corresponding stresses in each structural member, and the idealized structural mass of the final design. Simple user input combined with rapid iteration of analysis and design procedures and graphical output of design information permits early evaluation of the effect of changes in design variables. M.M.

**A71-23275 Man-oriented program system for engineering design.** George Rabe and Vincent A. Trossello (Bechtel Associates, New York, N.Y.). (*American Society of Civil Engineers, Conference on Electronic Computation, 5th, Purdue University, Lafayette, Ind., Aug. 31-Sept. 2, 1970.*) *American Society of Civil Engineers, Structural Division, Journal*, vol. 97, Jan. 1971, p. 223-235. 18 refs.

Description of a man-oriented system which engineers have created and are using for the design of industrial facilities. The system operates in time-sharing mode and has a modular structure. It was started with the design of large pressure vessels and is being expanded to encompass other engineering specialties. The system's structure and application closely follow the engineering design process and the method of operation of a particular design office. However, its basic principles and the ideas about the role of engineers in computerized design are generally applicable. M.M.

**A71-23286 # The development of compressor blades in composite materials.** Günter Niederstadt (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Forschungszentrum, Braunschweig, West Germany). *Deutsche Edelstahlwerke, International Symposium on Tendencies in the Development of Constructional Elements for Aero-Engines and Stationary Gas Turbines, Krefeld, West Germany, May 21, 22, 1970, Paper.* 9 p. In English and German.

Demonstration of the possibilities and limits of applicability of composite materials in aircraft engines. It is shown that a definite limit of applicability is set by the operating temperature. Plastic materials with boron and carbon fiber reinforcements attain the highest specific strength values and moduli of elasticity, but cover only a narrow service temperature range. Applications are therefore possible in the low-pressure compressor or in the first stages of the intermediate-pressure compressor. However, particularly in this range application will be rewarding, because the geometrical shapes of the blades are comparatively large and the weight savings - expressed in percentages - are substantial. A.B.K.

**A71-23288 # The problems of high-temperature corrosion.** Gustav Lennartz and Wolfgang Spyra. *Deutsche Edelstahlwerke, International Symposium on Tendencies in the Development of Constructional Elements for Aero-Engines and Stationary Gas Turbines, Krefeld, West Germany, May 21, 22, 1970, Paper.* 6 p. In English and German.

Discussion of high temperature corrosion in aircraft engine components, power plant turbines and other turbine installations. Sulfur contained in fuels, vanadium pentoxide and NaCl are considered as the principal corrosion agents. The mechanisms of corrosion by these agents and conditions stimulating corrosion occurrence are described. The recommended measures against these types of corrosion are listed as the minimization of corrosion agent contents in fuels, corrosion inhibitor additions to fuels (particularly SiO<sub>2</sub> with or without MgO), the use of more corrosion resistant alloys, and surface protection by Cr, Al, or Si coatings. V.Z.

**A71-23290 # Present state and trend of development of surface coating methods against oxidation and corrosion at high temperatures.** Günter Lehnert and Helmut Meinhardt. *Deutsche Edelstahlwerke, International Symposium on Tendencies in the Development of Constructional Elements for Aero-Engines and Stationary Gas Turbines, Krefeld, West Germany, May 21, 22, 1970, Paper.* 6 p. In English and German.

Review of the currently used protective coating techniques for turbine parts operating at high temperatures, and survey of trends in their development. The procedure used for applying aluminum-base coating on nickel and cobalt alloys is briefly described. The following trends in the development of protective coatings are discussed: (1) search for 'diffusion barriers' preventing aluminum diffusion into the material, (2) improvement of the adherence of protective coating and increasing its crack resistance, and (3) development of duplex coatings containing other elements - e.g., platinum for improving oxidation resistance. The protective coatings used for stationary gas turbines are briefly reviewed. Z.W.

**A71-23292 # Application and development trend of titanium alloys.** Albert Ismer. *Deutsche Edelstahlwerke, International Symposium on Tendencies in the Development of Constructional Elements for Aero-Engines and Stationary Gas Turbines, Krefeld, West Germany, May 21, 22, 1970, Paper.* 7 p. In English and German.

Analysis of the use and consumption of titanium in the aircraft industry with respect to the competition of other new materials. It is shown that during the past two decades the application of titanium in jet engines steadily increased. The titanium proportion reached a

certain saturation with 30% of the engine weight. Further increase seems to be possible only by the development of new titanium alloys for higher temperatures. The problems involved in the proper selection of alloy composition for high temperatures and improvement of structural stability that is closely connected with fracture toughness, fatigue, and stress corrosion are summarized. Research works for developing protective coatings on titanium for service temperatures above 500 C are discussed. Z.W.

**A71-23295 # 12% chromium steels and titanium-alloyed austenitic steels.** Herbert P. Wisniowski. *Deutsche Edelstahlwerke, International Symposium on Tendencies in the Development of Constructional Elements for Aero-Engines and Stationary Gas Turbines, Krefeld, West Germany, May 21, 22, 1970, Paper.* 11 p. 16 refs. In English and German.

Study of 12% chromium steels for short-time as well as long-time application. Their properties make them suitable for compressor disks, compressor rotor blades, and stator blades. Chromium steels with molybdenum, carbide-forming elements, and additions of cobalt have been subjected to metallurgical treatment to overcome a tendency to embrittlement at elevated temperatures. Of ferrous-based metals, only austenitic grades show a satisfactory creep-rupture behavior above 650 C. From the variety of austenitic steels available, only the titanium-alloyed types are discussed in detail. F.R.L.

**A71-23296 # Experiences with high-temperature coatings.** George Wile. *Deutsche Edelstahlwerke, International Symposium on Tendencies in the Development of Constructional Elements for Aero-Engines and Stationary Gas Turbines, Krefeld, West Germany, May 21, 22, 1970, Paper.* 6 p. In English and German.

Attempt to give some insight into the behavior of high temperature oxidation protective coatings, primarily from the viewpoint of the jet engine operator. Sulfidation products can be deposited on blades if coating defects occur during initial manufacture. In the absence of coating, erosion occurs quite commonly, and is due to carbon or, more rarely, to aluminum. Damage due to thermal cycling and particle impact is important. F.R.L.

**A71-23299 # Die forgings for aero engines and gas turbines.** Otto Voigtländer. *Deutsche Edelstahlwerke, International Symposium on Tendencies in the Development of Constructional Elements for Aero-Engines and Stationary Gas Turbines, Krefeld, West Germany, May 21, 22, 1970, Paper.* 17 p. In English and German.

Discussion of the manufacturing processes employed in the production of high-precision components for aircraft engines and stationary gas turbines. A review of advanced methods for forging and machining of blades, discs, and rings is presented. It is shown that using these methods, in combination with advanced joining processes, shapes and materials can be produced which closely meet the idea of the designer and consequently contribute to the improvement of the engines' efficiency. O.H.

**A71-23301 # Production of high-temperature materials at DEW with special regard to the foreseeable development.** Horst Spitzer and Otto Mülders. *Deutsche Edelstahlwerke, International Symposium on Tendencies in the Development of Constructional Elements for Aero-Engines and Stationary Gas Turbines, Krefeld, West Germany, May 21, 22, 1970, Paper.* 16 p. In English and German.

Description of the metallurgical processes employed at DEW (Deutsche Edelstahlwerke Aktiengesellschaft) in the production of high-temperature steels and alloys, with particular emphasis on those used for the manufacture of components for stationary gas turbines and aircraft engines. The extensive DEW's production program covering several types of high-temperature 12% Cr-steels, austenitic

Cr-Ni-steels, Co-Cr-Ni-steels and alloys, and nickel alloys is reviewed, and the respective fabrication technologies are described in detail. Principal future technological trends are outlined. Detailed attention is given to the interrelationships between production, quality control, and research and development. O.H.

**A71-23302 # High temperature nickel and cobalt alloys.** Florian Schubert. *Deutsche Edelstahlwerke, International Symposium on Tendencies in the Development of Constructional Elements for Aero-Engines and Stationary Gas Turbines, Krefeld, West Germany, May 21, 22, 1970, Paper. 12 p. 13 refs. In English and German.*

Review of some of the high-temperature strength mechanisms, capabilities, and limitations of the nickel-base and cobalt-base alloy families. The underlying alloying concept of each is briefly examined, and the mechanical behavior under stress and temperature is reviewed, along with the pertinent microstructural aspects. The contributory effects of individual alloying elements and of specific intermetallic phases are discussed. Special attention is given to grain structure effects. M.V.E.

**A71-23303 # Production and quality assurance of titanium and titanium alloys.** Klaus Rüdinger. *Deutsche Edelstahlwerke, International Symposium on Tendencies in the Development of Constructional Elements for Aero-Engines and Stationary Gas Turbines, Krefeld, West Germany, May 21, 22, 1970, Paper. 9 p. In English and German.*

Description of the arrangements employed for the production of titanium at a newly constructed plant incorporating the latest advances in smelting and fabrication technology. A number of processing steps based on technical and quality-control necessities are described, the purpose of which is to homogenize titanium sponge as the starting material and the alloying additions. The result of these arrangements is that the homogenization of ingots is shifted from the first melt to a stage before melting. A.B.K.

**A71-23307 # Development of components made of compound materials.** George Wile. *Deutsche Edelstahlwerke, International Symposium on Tendencies in the Development of Constructional Elements for Aero-Engines and Stationary Gas Turbines, Krefeld, West Germany, May 21, 22, 1970, Paper. 6 p. In English and German.*

Discussion of several jet engine component designs using metallic and nonmetallic composite materials which appear to be attractive in some applications. The applications considered include an integral blades/disk design with a glass fiber winding, a replaceable blade concept using glass, a selective reinforcement hoop using glass/resin airfoils stiffened with boron, and a hoop-supported rotor design using glass/resin materials. The design problems involved when such materials are used, such as maintenance and nondestructive testing, are discussed. V.Z.

**A71-23420 # Asynchronous generators for aircraft (Aviatsonnyye asinkhronnye generatory).** N. D. Toroptsev. Moscow, Izdatel'stvo Transport, 1970. 204 p. 35 refs. In Russian.

Energy supply systems for aircraft are briefly reviewed and, in particular, principal sources of alternating current for aircraft are considered in terms of the present state of development and future trends. Theoretical principles underlying the design of asynchronous generators and principal characteristics of these generators are presented. Parallel operation of asynchronous self-excited generators is discussed in detail. Particular emphasis is placed on one possible solution to the problem of generating alternating three-phase current of stable frequency in case of variable speeds of rotation of driving aircraft engines, which is based on the application of asynchronous generators with synchronous current. O.H.

**A71-23423 \* # Further correlation of data from investigations of a high-subsonic-speed transport aircraft model in three major transonic wind tunnels.** Stuart L. Treon, Frank W. Steinle (NASA, Ames Research Center, Moffett Field, Calif.), John R. Hagerman (USAF, Aeronautical Systems Div., Wright-Patterson AFB, Ohio), John A. Black (ARO, Inc., Arnold Engineering Development Center, Arnold Air Force Station, Tenn.), and Robert J. Buffington (Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y.). *American Institute of Aeronautics and Astronautics, Aerodynamic Testing Conference, 6th, Albuquerque, N. Mex., Mar. 10-12, 1971, Paper 71-291. 15 p. 8 refs. Members, \$1.50; nonmembers, \$2.00.*

A second series of wind tunnel tests has been conducted to assess the 'probable best expectancy' of agreement of static aerodynamic data obtained for an airplane configuration in the NASA Ames Research Center 11- by 11-foot, Arnold Engineering Development Center 16-foot, and Cornell Aeronautical Laboratory 8-foot transonic wind tunnels. This second series of tests was conducted to prevent potential sources of error and ambiguity in the data encountered in an initial series of tests previously reported. In addition, an experimental assessment was made of the influence of flow quality and zero-lift blockage on the data correlation for the three facilities. 'Best expectancy agreement' is determined for static aerodynamic data obtained in the featured facilities for state-of-the-art instrumentation and test procedures as currently practiced. This agreement, although quite good, is less than desirable relative to current goals. Corrections to the data based on advanced test procedures defining relative buoyancy and stream turbulence indicate strong promise of improved correlation of data between facilities. (Author)

**A71-23424 Fuel tank environments and sealant requirements for the supersonic transport.** Marlan R. Pollock (Boeing Co., Commercial Airplane Group, Renton, Wash.). *SAMPE Journal*, vol. 7, Feb.-Mar. 1971, p. 19-22, 48.

The standard procedure for evaluating the suitability of a material for a particular application is to subject it to the operating environment and measure the effect on properties. More often than not, especially for aircraft, the environment is a combination of factors complicated by individual variations in time and intensity of each. As a rule, exposing the material to cycling combinations is more severe than exposing it to a portion of the environment; therefore, it is important to establish the laboratory environment as realistically as possible. The following is the approach taken by Boeing to do this for fuel tank sealants for the SST. (Author)

**A71-23427 Fabrication of titanium structures.** J. L. Spehr and T. B. Runge (McDonnell Aircraft Co., St. Louis, Mo.). *SAMPE Journal*, vol. 7, Feb.-Mar. 1971, p. 39-44, 54.

It is pointed out that in present-day fighter aircraft, most titanium alloy applications are in areas which are subjected to high temperatures but are relatively lightly loaded. Titanium properties are examined. To fabricate titanium structures for advanced aircraft, both newly developed and proven forming, metal removal and assembly techniques are employed. Titanium assemblies fabricated to demonstrate the applicability of the fabrication and assembly methods described are considered. G.R.

**A71-23440 # Studies on the gust response of a wing. I - Response of a two-dimensional rigid wing.** Hiroshi Maeda (Kyoto University, Kyoto, Japan) and Makoto Kobayakawa (Kansai University, Osaka, Japan). *Kyoto University, Faculty of Engineering, Memoirs*, vol. 32, Oct. 1970, p. 379-404. 14 refs.

Investigation of the response characteristics of a two-dimensional rigid wing to gusts, which vary normal to the main flow sinusoidally and randomly. In the case of a sinusoidal gust, experimental results show that the absolute values of lift variations

are less than those of Sears' function, and phase differences are large. In the analyses the thickness effects of airfoil sections are investigated. For the case of a random gust, generalized harmonic analyses are applied. The frequency transfer functions of lift have a different inclination from those of Sears' function in the experimental results. From the power spectral function of circulations the frequency transfer function of lift is obtained analytically, and the difference between the experimental results and the calculated ones is discussed. F.R.L.

**A71-23539 Effective stress concentrations for fillets in landed structures.** Clarence R. Smith. (*Society for Experimental Stress Analysis, Fall Meeting, Houston, Tex., Oct. 14-17, 1969.*) *Experimental Mechanics*, vol. 11, Apr. 1971, p. 167-171.

Description of a method for correcting stress calculation factors at fillets in landed structures. An attempt is made to show the relationship between maximum load per gross area stress and the factor by which handbook values for stress concentrations should be multiplied to obtain true stress. Stress concentrations at fillet radii are corrected for bending caused by misalignment between land and adjacent structure. O.H.

**A71-23577 A note on the calculation of 'cut-off' Mach number.** J. M. Nicholls. *Meteorological Magazine*, vol. 100, Feb. 1971, p. 33-46. 6 refs.

The paper gives a theoretical derivation of the Mach number which an aircraft must reach in order that any sonic bang produced will just reach the ground ('cutoff' Mach number). The derived formula is compared with a derivation, used in other literature, which was based on an incorrect assumption. A method of calculation of cutoff Mach number is presented together with an assessment of the probable errors in the calculated value. (Author)

**A71-23578 On the asymptotic behavior of solutions of the Prandtl boundary layer equations.** Wolfgang Walter. *Indiana University Mathematics Journal*, vol. 20, Mar. 1971, p. 829-841. 9 refs. Contract No. DA-31-124-ARO(D)-462.

The Prandtl equations for steady laminar two-dimensional flow past a rigid body are analyzed for the conventional boundary conditions plus a condition at infinity. Upper and lower convergence estimates are obtained for several cases. The boundedness of solutions is examined. The behavior of the velocity component in the x direction at large distances from the body is determined. V.P.

**A71-23579 # Progress towards certification with Concorde.** S. G. Corps (Air Registration Board, London, England). *Aircraft Engineering*, vol. 43, Mar. 1971, p. 12-16, 19-21, 29.

Airworthiness requirements for the supersonic transport Concorde are examined, and the participation of the Air Registration Board in the flight test program is described. One of the more interesting aspects of development flying is discussed, and a hypothetical SST flight is described. General features and generic differences that a slender delta transport aircraft present are pointed out. The design of the flight deck is considered, and nose and visor positions available for various phases of flight are shown. Some details regarding takeoff are presented. Characteristics of supersonic flight are explored. Transonic static stability for various heights, the effect of Mach trim, skin equilibrium temperatures and static stability at high incidence are among the subjects considered. Aspects of the descent part of the flight are investigated. The importance of good vision for the pilot is discussed in connection with the landing operation. G.R.

**A71-23580 # Thermal fatigue test installation for Concorde.** H. G. Hirschberg (Sulzer Brothers, Ltd., London, England). *Aircraft Engineering*, vol. 43, Mar. 1971, p. 22, 27-29.

It is pointed out that in a supersonic aircraft stresses in addition to those present in subsonic aircraft are produced in the structural materials by rapid temperature changes occurring on the skin of the aircraft and the temperature gradients connected with these changes. An altitude-speed diagram of a typical supersonic flight is discussed. Approaches for the conduction of fatigue tests are described. The control of air temperature is considered. It was decided to control temperature by variation of the transfer temperature in a single heat exchanger block. Studies of heat and cold storage methods are reported. A test cycle consisting of the climb phase, the cruise phase, the descent phase, and the recovery phase is described. Reservoir installations, refrigerating equipment, and air ducts are discussed. G.R.

**A71-23581 # Fuel management for Concorde.** H. G. Turner (Plessey Co., Ltd., Plessey Dynamics Group, Ilford, Essex, England). *Aircraft Engineering*, vol. 43, Mar. 1971, p. 36, 39.

The importance of keeping the relationship between the center of gravity and the center of pressure within predetermined limits in order to maintain the trim of a supersonic aircraft is emphasized, and measures taken to accomplish this by appropriate transfer of fuel between sections of the aircraft during the flight are discussed. It is pointed out that in addition to its use for the aircraft propulsion engines, fuel is also used as a very convenient medium for cooling sections of the aircraft. Some details are presented regarding the fuel pumps used for the Concorde. G.R.

**A71-23582 # Developments in electrochemical marking of components.** R. Ayers (Lectroetch /Great Britain/, Ltd., England). *Aircraft Engineering*, vol. 43, Mar. 1971, p. 38, 39.

The importance of markings for aircraft components, especially those which differ from each other by only very small variations in form or dimensions, is pointed out. The penetration involved makes marking by stamping and engraving unacceptable when dealing with highly stressed parts or thin materials. Electrochemical or electrolytic marking of components has, therefore, been widely used in the Concorde project. The introduction of this process, its characteristics, and the equipment involved are discussed. G.R.

**A71-23583 # Environmental testing of Concorde components.** K. J. C. MacMaster (Industrial Furnaces, Ltd., Brierley Hill, Staffs., England). *Aircraft Engineering*, vol. 43, Mar. 1971, p. 40, 41.

The necessity of designing new test facilities in connection with aircraft development work is shown. A facility designed for conducting endurance tests with the accessory drives system of the Olympus 593 engine at simulated flight conditions for a minimum of 4,000 hours is described. Other test facilities discussed include thermal shock rigs and a plant for simulating the air supply tapped from the compressor stages of aircraft propulsion gas turbine engines for the purpose of testing and developing items of aircraft air conditioning equipment. G.R.

**A71-23601 # Calculation of the three-dimensional flow in an axial turbomachine (Calcul de l'écoulement tridimensionnel dans une turbomachine axiale).** Robert Legendre. *La Recherche Aérospatiale*, Jan.-Feb. 1971, p. 1-6. 9 refs. In French.

Factors involved in the calculation of the flow are examined, and a geometric definition of each cascade is given. The flux vector is defined by two families of conjugate stream surfaces which are determined by a series expansion whose coefficients are unknown functions. The dynamics vector equation considered provides a set of relations for determining the unknowns. The junction conditions of the flows through and around the cascades are briefly discussed. G.R.

**A71-23603 #** On some properties of turbulence in supersonic flows (Sur quelques propriétés de la turbulence dans les écoulements supersoniques). Jean Gaviglio (CNRS, Paris, France). *La Recherche Aéronautique*, Jan.-Feb. 1971, p. 17-24. 28 refs. In French.

Approaches introduced by Kovaszny (1953) to study turbulence in supersonic flow by considering three modes involving vorticity, entropy, and acoustic aspects are examined. The solution of the linearized equation in a specific case is considered. The characteristics of the three modes are investigated separately, and conditions at their superposition are explored. The effect of each of the three modes on a hot wire anemometer is examined. Characteristics of turbulence as a function of the Mach number are discussed taking into account conditions at the boundary layer. Results obtained in a number of flow investigations are evaluated. It is pointed out that the mode involving the entropy is present in all flows. Attention is given to the interpretation of measurements of velocity and temperature at Mach numbers greater than five, and mode interaction in case of more intense fluctuations is briefly considered. G.R.

**A71-23605 #** Study of the coexistence of a supersonic jet and of a subsonic jet in a constant section duct (Etude de la coexistence d'un jet supersonique et d'un jet subsonique dans un canal à section constante). Jacques Paulon. *La Recherche Aéronautique*, Jan.-Feb. 1971, p. 33-39. In French.

The experimental setup, in which a duct of rectangular cross section with a height much larger than its width was used, is described. The flow was analyzed by making use of pressure readings on the walls and within the fluid. The results provided a basis for the characterization of the actual boundaries of the two flows, as well as the transition domain between them. The schlieren visualization of the flow confirms the results drawn from the pressure readings. G.R.

**A71-23606 #** Application of the 'branch-modes' method to the prediction of the vibrational behavior of a helicopter in flight (Application de la méthode 'modes partiels' à la prévision du comportement vibratoire d'un hélicoptère en vol). Pierre-Marie Hutin. *La Recherche Aéronautique*, Jan.-Feb. 1971, p. 41-50. In French.

The method discussed consists in establishing the modal scheme of the whole helicopter by superposition of the modal schemes of different parts defined by ground resonance tests. Thus, the structure without blades and the blades are considered separately. The validity of the approach is demonstrated by an experimental investigation made on the structure of rotors mounted on a support in an experimental installation and on a helicopter. G.R.

**A71-23607 #** Acoustic effects due to gas jets (Efecte acustice datorite jeturilor de gaze). C. Teodorescu-Tîntea (IMFCA, Rumania). *Studii și Cercetări de Mecanică Aplicată*, vol. 30, no. 1, 1971, p. 3-24. 14 refs. In Rumanian.

Description of the results of original investigations of the structure of a free turbulent jet and the cause of aeroacoustic phenomena in jets. On the basis of conclusions reached by the author, a correlation between noise and turbulence is underlined, and the characteristics of the near and far acoustic fields generated by gas jets at subsonic and critical velocities are analyzed. M.M.

**A71-23608 #** Supersonic flow around a cross-shaped tail plane having the horizontal plane with supersonic leading edge, considering flow separation from the subsonic leading edge of the plate (Mișcarea supersonică în jurul unui ampenaj cruciform avînd planul orizontal cu bordul de atac supersonic, considerînd desprinderile de curent de la bordurile de atac subsonice ale plăcii). Ștefan Staicu (București, Institutul Politehnic Gheorghe Gheorghiu-Dej, Bucharest, Rumania). *Studii și Cercetări de Mecanică Aplicată*,

vol. 30, no. 1, 1971, p. 39-51. 11 refs. In Rumanian.

As in the case of a slender delta wing with equal but opposite sign incidence on both of its halves, in the case of a cross-shaped tail plane with three branches the flow separates at the edges of the plate in the form of conical horns. Treating the problem indirectly as for the case of a plain delta wing, a theoretical study model is established through which the pressure distribution and aerodynamic characteristics of the cross-shaped tail plane are obtained. M.M.

**A71-23609 #** Aeroelastic stability of plane sandwich plates placed in a supersonic gas flow (Stabilitatea aeroelastică a structurilor plane de tip sandviș, plasate într-un curent de gaz supersonic). L. Librescu and Eleonora Malaiu (Academia Română, Institutul de Mecanică Fluidelor, Bucharest, Rumania). *Studii și Cercetări de Mecanică Aplicată*, vol. 30, no. 1, 1971, p. 171-196. 28 refs. In Rumanian.

Particular attention is devoted to the problem of the aeroelastic stability of infinite sandwich panels. The influence of the parameter which expresses the flexibility of the transverse shear of the structure and the parameter connected with the axial loads on the critical magnitudes (flutter and divergence) is investigated. The conclusions reached in other recent works regarding the lack of agreement between a series of results in this field obtained in exact and approximate fashion are examined and justified. M.M.

**A71-23615 #** Determination of the generalized aerodynamic forces acting on a harmonically oscillating wing in subsonic flow (Определение обобщенных аэродинамических сил, действующих на гармонически вибрирующее крыло в дозвуковом потоке). Zdenek Shkoda. (Conférence Nationale de Mécanique Appliquée, Bucharest, Rumania, June 23-27, 1969.) *Revue Roumaine des Sciences Techniques, Série de Mécanique Appliquée*, vol. 15, no. 6, 1970, p. 1325-1342. 8 refs. In Russian.

Development of a method for solving a linearized problem of an oscillating wing of finite span in a subsonic flow of an ideal gas. The lifting surface of the thin wing is replaced by a lifting line system, which under steady motion turns into the usual system of lifting vortices. The integral equation of the lifting surfaces is then replaced by a system of one-dimensional singular integral equations. The computations are performed on a high-speed computer for any wing planform and number of degrees of freedom of wing surface deformation. The results are used mainly for critical wing flutter calculations. M.V.E.

**A71-23616 #** On the 'reflection' of the Mach cones at the subsonic leading edges of a thin wing in supersonic flow. Dan Mateescu (IMFCA, Bucharest, Rumania). (Conférence Nationale de Mécanique Appliquée, Bucharest, Rumania, June 23-27, 1969.) *Revue Roumaine des Sciences Techniques, Série de Mécanique Appliquée*, vol. 15, no. 6, 1970, p. 1343-1356. 5 refs.

A procedure is discussed for treating the problem of motion inside a reflected Mach cone - i.e., the Mach cone issuing from the point where another Mach cone (issued from the vertex of a thin wing) intersects a subsonic leading edge. The purpose of the procedure is to determine the axial disturbance velocity on the wing and to establish the resulting additional pressure distribution on the wing portion affected by the reflected Mach cone. This involves a mixed type problem, whose solution is arrived at with the aid of the method of hydrodynamic analogy elaborated by Carafoli (1956) for the study of high order conical flows. As an application example, the case of a thin rectangular wing of low aspect ratio is treated. M.V.E.

**A71-23617 #** The delta wing of symmetrical thickness with variable geometry, optimum for two supersonic cruising speeds. Adriana Năstase (București, Institutul Politehnic Gheorghe Gheorghiu-Dej, Bucharest, Rumania). (Conférence Nationale de Mécanique Appliquée, Bucharest, Rumania, June 23-27, 1969.)

*Revue Roumaine des Sciences Techniques, Série de Mécanique Appliquée*, vol. 15, no. 6, 1970, p. 1357-1373. 8 refs.

Discussion of approaches to determining the shape of a delta wing of symmetrical thickness and of optimum variable geometry for two supersonic velocities, with zero thickness along the leading and trailing edges of the open and closed wing. The determination is arrived at by solving the two extremum problems in cascade for the closed and open delta wing. The use of the variational method makes it possible to reduce each problem to the solving of a finite algebraic system of linear equations. M.V.E.

**A71-23618 # Interaction of a laminar boundary layer with a shock wave in a compression corner (Interaction d'une couche limite laminaire avec une onde de choc dans un coin de compression).** A. A. Sfeir (California, University, Berkeley, Calif.). (*Conférence Nationale de Mécanique Appliquée, Bucharest, Rumania, June 23-27, 1969.*) *Revue Roumaine des Sciences Techniques, Série de Mécanique Appliquée*, vol. 15, no. 6, 1970, p. 1375-1391. 9 refs. In French.

The problem of viscous supersonic flow separation near a concave compression corner is considered. In contrast to other studies of this problem concerned with the total flow behavior, the objective of this study is limited to detailed measurements of the laminar layer designed, among other things, to test Chapman's (1958) isentropic recompression hypothesis and the gradient hypothesis viewing normal pressure gradients as negligible. Detailed experiments of two-dimensional flow about a compression corner at velocities near 2.65 M have led to several significant results, including the validation of the two hypotheses. M.V.E.

**A71-23663 # Wind tunnel tests of a wing with blowing on the bottom surface of the profile (Badania aerodynamiczne płata z wydymuchem na dolnej powierzchni profilu).** Robert Józwiak and Andrzej Moldenhawer. *Instytut Lotnictwa, Prace*, no. 42, 1970, p. 3-20. 15 refs. In Polish.

Wind-tunnel tests of a NACA 23015 airfoil having different blowing nozzle arrangements on the bottom overpressure surface at air speeds of 18 and 30 m/sec. Measurements were made with a continuous blowing slot extending across the entire span and with arrangements of three circular and oval nozzles. The air blown from the continuous slot caused flow turbulence and resulted in irregular aerodynamic characteristics. The maximum lift coefficient of such a wing does not exhibit a regular dependence on the blowing coefficient. The pitching moment coefficient at zero angle of attack changes sign twice in the examined range of blowing coefficients, and the minimum drag coefficient increases very rapidly with higher blowing coefficients. The wings with circular and oval nozzles have regular aerodynamic characteristics and show promise for practical applications. T.M.

**A71-23667 # Studies of profile drag in flight (Badania oporu profilowego w locie).** Wanda Bartosik and Julian Bojanowski. *Instytut Lotnictwa, Prace*, no. 42, 1970, p. 71-84. 10 refs. In Polish.

The moments method was used to measure the in-flight profile drag of gliders with two different sensor arrangements for the total and static pressures in the boundary layer wake. One probe arrangement consisted of a comblike configuration of pressure sensing tubes connected to a bank of manometers. An improved version consisted of a sliding pressure tube and a self-adjusting pitot tube. Test data are given for the velocity distributions in the boundary layer wakes of different profiles and for the effects of air brakes on the profile drag. T.M.

**A71-23669 # Loads on a rigid glider during towed flight in a turbulent atmosphere (Obciążenia sztywnego szybowca w locie holowanym w burzliwej atmosferze).** Justyn Sandauer. *Instytut Lotnictwa, Prace*, no. 43, 1970, p. 3-53. 24 refs. In Polish.

Analysis of the effect of glider and tow-system characteristics on the difference in the maximum loading of a glider in turbulent air under free- and towed-flight conditions. The air turbulence is assumed as a rotor-wave gust with sinusoidal speed distribution and variable length. A method is proposed for estimating the effects of the main glider parameters and tow-flight conditions on the behavior of loading. In the calculation, an analog computer was used. It is shown that the value of the second maximum of the load factor can be higher during towing than under free-flight conditions. The conditions under which this increase in the maximum load can be expected are determined. Practical recommendations are given for the towing of a glider in air turbulence, including initial attitude with respect to the towing aircraft, length of the tow cable, and dynamic characteristics of the tow cable-glider system. Z.W.

**A71-23670 # Helicopter takeoff taking advantage of the kinetic energy of the rotor inertial system (Start śmigłowca z wykorzystaniem energii kinetycznej inercyjnego układu wirnika nośnego).** Kazimierz Szumański. *Instytut Lotnictwa, Prace*, no. 43, 1970, p. 55-79. 7 refs. In Polish.

The possibility of reducing the engine power reserves required for the start of a helicopter from a hover state is examined together with the utilization of the kinetic energy of the rotor inertial system during acceleration above ground. The parameters of helicopter motion during takeoff from hovering are analyzed. The acceleration stage of the takeoff is examined taking into consideration the following effects: (1) initial angular velocity of rotor, (2) initial power excess, (3) flight altitude, and (4) acceleration of the helicopter. A numerical example is presented for illustrating a simplified takeoff analysis with allowance for the utilization of the kinetic energy of rotor inertial system. Z.W.

**A71-23672 # Experimental studies of the position of the stagnation line on blunt bodies with a sharp edge (Badania doświadczalne położenia linii krytycznej na tępych ciałach o ostrej krawędzi).** Jerzy Stasiak. *Instytut Lotnictwa, Prace*, no. 44, 1970, p. 39-56. 7 refs. In Polish.

Experimental study of the position of a circular stagnation line relative to a circular sharp edge on an axisymmetrical blunt body consisting of a cylinder terminated by a spherical surface at the front. Wind-tunnel tests were conducted at Mach-1.52 velocities to verify the effect of stagnation-line motion away from the circular edge, previously observed at Mach 2.3. It is shown that the sharp circular edge can not be identified with the stagnation line even when the radius governing the position of the circular edge on the body is larger than the radius of the stagnation line on the spherical surface. The stagnation line in this case remains on the spherical frontal portion of the body and does not 'jump' to the edge. T.M.

**A71-23675 # Symbolic flight displays.** Steven L. Johnson and Stanley N. Roscoe (Illinois, University, Urbana, Ill.). *Naval Research Reviews*, vol. 24, Feb. 1971, p. 1-13. 13 refs.

Research conducted for improving performance of Navy pilots through use of dynamic, symbolic flight displays is discussed. A major problem in the design of symbolic displays has been the question of movement relationships between symbols representing the aircraft and those representing the outside world, and the effects of these relationships on control reversals experienced by pilots. The research described involves in-flight comparisons between the conventional flight director display and an experimental display with novel movement relationships. G.R.

**A71-23690 Corrosion resistant adhesive bonding.** Robert H. Greer (Rohr Corp., Chula Vista, Calif.). *SAMPE Quarterly*, vol. 2,

Jan. 1971, p. 51-60.

An adhesive bonded sandwich structure typical of airframe component construction and triple adhering bonded metal to metal test specimens were exposed to outdoor weathering and salt spray environments. The triple adherend test specimens of bare and alclad 2024 aluminum were bonded with several adhesive and primer combinations. After bonding, they were machined and fitted with rivets and bolts to simulate the assembly procedures used in the manufacture of the airframe component. The specimens were dissected and examined after the exposure tests for bond line corrosion. Based on the results of these tests, changes in current design practices for adhesive bonded structures are recommended.

(Author)

**A71-23691**      **The case for precision forgings and pressings.**  
John Noyes, Jr. (McDonnell Aircraft Co., St. Louis, Mo.). *SAMPE Quarterly*, vol. 2, Jan. 1971, p. 61-65.

Description of precision forging and pressing techniques for aluminum and titanium parts of aircraft structures. The general features of precision forging with respect to conventional forging techniques are discussed. The parts designed for precision forging have draft angles equal to zero or near zero where needed, webs and radii are accepted smaller than usual, and overall tolerances are reduced. A pressing has all the features of a precision forging plus having no flash and no mismatch. This is achieved by additional dies to confine the sides of the working metal. The economic aspects of precision forging are discussed, taking into account savings in machining expenditures and the need for more expensive forging equipment.

Z.W.

**A71-23696 #**      **Preparations and experiences connected with B-747 passenger handling in Frankfurt (Vorbereitungen und Erfahrungen bei der Abfertigung der B-747 in Frankfurt).** R. Lange. *Arbeitsgemeinschaft Deutscher Verkehrsflughäfen, Jahresversammlung, 22nd, Mönchengladbach, West Germany, Oct. 21, 22, 1970, Paper. 5 p.* In German.

Description of the special measures taken to facilitate the passenger flow to and from Boeing 747s using the Frankfurt airport. Measures taken to facilitate passenger loading and unloading, baggage claim for arriving passengers, and customs control are described. The use of three passenger gangways for the boarding and disembarking of passengers is cited as an especially convenient feature. A brief comparison is made between the noise level experienced with the B-747 and the noise caused by the B-707.

A.B.K.

**A71-23759 #**      **An existing system in the aircraft industry - The British Aircraft Corporation Numerical Master Geometry system.** M. A. Sabin (British Aircraft Corp., Ltd., Weybridge, Surrey, England). *Royal Society (London), Proceedings, Series A*, vol. 321, no. 1545, Feb. 9, 1971, p. 197-205. 8 refs.

Description of the characteristics of the Numerical Master Geometry (NMG) system, employing parameter surface mathematics, which is in use at British Aircraft Corporation. With the aid of this system the external shape of aircraft can be represented numerically in a form allowing the necessary information for design and manufacture using a digital computer. The parametric form used for surface definition is described, and surfaces thus generated are illustrated. Advantages of parametric representation are discussed, and some features of future development are outlined.

O.H.

**A71-23762 #**      **The use of roughness to trigger off transition in a bubble at the leading edge of an aerofoil at high incidences.** E. Erlich and M. Pinoteau (ONERA, Châtillon-sous-Bagneux, Hauts-de-Seine, France). (*Supersonic Tunnel Association, Meeting, 35th, Dallas, Tex., Mar. 8, 9, 1971.*) *ONERA, TP* no. 923, 1971. 4 p. 20 refs.

It is shown that surface roughness can be used to ensure turbulent reattachment at low Reynolds numbers on airfoil sections where separation occurs near the leading edge at high incidences. The separation occurring near the leading edge produces a more or less sizeable bubble depending on whether the reattachment takes place still under laminar or already under turbulent flow conditions (transition within the bubble). Laminar-to-turbulent transition in the bubble can be achieved by roughening the leading edge in a suitably arranged pattern upstream of the pressure minimum. The roughness changes a bubble with laminar reattachment into a short bubble (turbulent reattachment). The roughness height can be determined from the known value of the roughness Reynolds number.

T.M.

**A71-23804 #**      **Small parameter method in the theory of gyrocompass (O metode malogo parametra v teorii girokompasov).** V. P. Vasilenko (Akademiia Nauk Ukrainskoi SSR, Institut Matematiki, Kiev, Ukrainian SSR) and A. P. Ianishevskii (Akademiia Nauk Ukrainskoi SSR, Institut Gidromekhaniki, Kiev, Ukrainian SSR). *Ukrainskii Matematicheskii Zhurnal*, vol. 23, no. 1, 1971, p. 70-75. 5 refs. In Russian.

Application of the small parameter method for solving some analytical problems of the theory of gyrocompass is discussed. A system of differential equations is derived for describing the motion of the sensitive element of a two-rotor gyrocompass which has not the properties of a spatial gyrohorizon compass. Fundamental solutions to these differential equations are derived by using the small parameter method. The eigenvalues of a monodromy matrix are analyzed to determine the stability of a zero solution of these equations.

V.Z.

**A71-23813**      **Development of combustion reactions in the presence of a velocity gradient downstream of a steady shock wave (Développement des réactions de combustion en présence d'un gradient de vitesse en aval d'une onde de choc stationnaire).** Jean-Claude Bellet, Jacques Soustre, and Numa Manson (Toulouse, Centre d'Essais Aéronautiques, Toulouse; Ecole Nationale Supérieure de Mécanique Appliquée, Poitiers, France). *Académie des Sciences (Paris), Comptes Rendus, Série A - Sciences Mathématiques*, vol. 272, no. 1, Jan. 4, 1971, p. 67-70. 9 refs. In French.

The aerodynamic field in the induction region of a combustion stabilized by Mach effects in a supersonic wind tunnel was studied, the gases were analyzed, and the flame temperatures measured. The data thus obtained made it possible to determine how combustion reactions develop in the presence of a velocity gradient and to ascertain the possibility of a reaction freeze in certain cases.

M.V.E.

**A71-23822**      **The problem of the flow around a rectilinear profile placed in a current of finite width in linear theory (Sur le problème de l'écoulement autour d'un profil rectiligne placé dans un courant de largeur finie en théorie linéaire).** Pierre Capodanno (Besançon, Université, Besançon, France). *Académie des Sciences (Paris), Comptes Rendus, Série A - Sciences Mathématiques*, vol. 272, no. 2, Jan. 11, 1971, p. 157-159. In French.

Consideration, in the plane  $z = x + iy$ , of a uniform current of finite width, of velocity  $U$  parallel to the real axis,  $U$  being assumed to be sufficiently large so that the effect of gravity can be neglected. A rectilinear profile is introduced into the current. The new flow is assumed to be steady and nonrotational. An attempt is made to establish an approximate expression of the complex potential  $f(z)$ , and to calculate the forces exerted on the profile by the fluid.

F.R.L.

**A71-23824**      **Asymptotic study of the sonic flow of a dissipative fluid at a great distance from a symmetrical plane barrier (Etude asymptotique de l'écoulement sonique d'un fluide dissipatif à grande distance d'un obstacle plan symétrique).** Jacqueline Hubert

(Paris, Université, Département de Mécanique, Paris, France). *Académie des Sciences (Paris), Comptes Rendus, Série A - Sciences Mathématiques*, vol. 272, no. 2, Jan. 11, 1971, p. 168-171. 6 refs. In French.

Completion of previous work (1968) by study of what the shock and flow conditions become downstream of the shocks. For the latter, two developments are considered, one called 'exterior,' which is outside the wake, and the other called 'interior,' which is within the wake. The linking-up is made according to the classical method of Kaplun-Lagerstrom. F.R.L.

**A71-23855** **Determination of the instantaneous flow velocity in a pulsed subsonic wind tunnel (Détermination de la vitesse instantanée dans la veine d'une soufflerie subsonique pulsée).** Roger Barriol (Orléans, Université, Orléans, France). *Académie des Sciences (Paris), Comptes Rendus, Série A - Sciences Mathématiques*, vol. 272, no. 8, Feb. 22, 1971, p. 555-557. 5 refs. In French.

The flow profile in a pulsed subsonic wind tunnel is determined with allowance for the boundary layer thickness at the walls for a constant velocity equal to the mean velocity of the flow. The correction for the boundary layer thickness, with a view toward obtaining a completely homogeneous pulsed flow, is made by determining the corrections that must be applied to the velocity at each moment of time and in each section of the flow, taking into account the nonlinear element introduced by the boundary layer. V.P.

**A71-23928** **Data processing in the experimental flight technology (Datenaufbereitung in der Flugversuchstechnik).** Lothar Koch (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Institut für Dynamik der Flugsysteme, Oberpfaffenhofen, West Germany). *DFVLR-Nachrichten*, Mar. 1971, p. 145-147. In German.

It is pointed out that the success of flight experiments in connection with the investigation of problems of flight mechanics and control depends largely on the quality of the data processing. The requirements of data processing equipment needed are examined. The use of a digital computer of the type Honeywell H 516 for organizing the flow of the measurement data and for controlling the operation of all subsystems and devices is discussed. G.R.

**A71-23936** **Study of unsteady low Mach number flows with application to aerodynamic noise (Etude des écoulements instationnaires à faible nombre de Mach avec application au bruit aérodynamique).** Henri Viviani (ONERA, Châtillon-sous-Bagneux, Hauts-de-Seine, France). *Journal de Mécanique*, vol. 9, Dec. 1970, p. 573-599. 10 refs. In French.

Consideration of the general problem of calculating an unsteady low Mach number flow by a perturbation method in which the solution is represented by expansions with respect to a characteristic Mach number. It is shown that these expansions, called inner expansions, are not uniformly valid at great distances, owing to the unsteady character of the flow. The problem is therefore one of singular perturbation and is treated by the method of matched asymptotic expansions. The solution at great distances is represented by outer expansions which lead to the acoustic approximation and thus represent the acoustic field generated by the flow. With the aid of the matching conditions, which are treated in detail, the first three terms of the outer expansion of the pressure are determined as a function of certain characteristics of terms of the inner expansion of the pressure. A.B.K.

**A71-23938 #** **Direct measurement of fatigue damage in aircraft.** E. J. Blackburn (Hawker Siddeley Aviation, Ltd., Kingston-on-Thames, Surrey, England). *Strain*, vol. 7, Jan. 1971, p. 25-30. Research supported by the Ministry of Technology.

Description of a fatigue life gauge for aircraft, mounted on a mechanical amplifier and bonded to a structure, for integrating the

load/frequency pattern to which it is exposed. The purpose of the device is to compare the rate of loading, accumulated by a test structure, with the rate accruing to similar structures undergoing variable service loading. Inasmuch as this loading affects the fatigue life of a component, the device will monitor fatigue damage. Some agreement is shown between laboratory test of an aircraft fin and measurements taken during routine flying. The device is sensitive to change in aircraft use. M.M.

**A71-23943** **ILS and the microwave landing system.** E. R. Holm (Cutler-Hammer, Inc., Deer Park, N.Y.). *Interavia*, vol. 26, Feb. 1971, p. 142, 143.

Review of the accelerating progress toward the next generation microwave ILS, which indicates that a new international standard could be achieved in this decade. ILS limitations and improvements, and a modular solid-state ILS design, are discussed. Some improvements in the availability and usefulness of ILS are believed obtainable by rational changes in rules or procedures. It is expected that the ILS will have another 25 years of life before retirement. F.R.L.

**A71-23944** **V/STOL controls and displays.** R. W. Howard (Elliott Flight Automation, Ltd., Rochester, Kent, England). *Interavia*, vol. 26, Feb. 1971, p. 144-146.

Consideration of the automatic flight control system requirements for V/STOL aircraft, which are expected to benefit substantially from recent developments in electronic displays. The flight control requirements for pure STOL are not likely to be very different from those of current CTOL aircraft. Autostabilization and computing must be incorporated into the manual flying control system of the VTOL aircraft in order to improve the handling qualities, to vary the lift and control effectiveness against the lift engines during transition, and to provide automatic compensation for lift engine failure. One of the major developments in avionics is electronic head-down displays. These developments aim to provide the crew of an aircraft with more substantial and better information in a manner which is more readily assimilated. F.R.L.

**A71-23946** **An operational aid for warning of aquaplaning conditions.** J. E. Forbat (Inertia Switch, Ltd., Camberley, Surrey, England). *Interavia*, vol. 26, Feb. 1971, p. 164-166.

Consideration of aircraft skidding accidents due to aquaplaning, and of means of preventing them. Trials conducted at Wallops Island, Va., and Cranfield, Beds., are reviewed, which indicate that runway resurfacing or grooving will reduce aquaplaning occurrences on a fairly high proportion of occasions, but at high cost. The APRIL (AquaPlaning Risk Indicator for Landings), a water depth sensor capable of measuring, relative to a specified datum, to within one or two thousandths of an inch, is described. It employs discrete probes accurately set in a shallow steel dome which is bolted into the runway and is strong enough to take the rolling weight of heavy jet transports. The system is relatively inexpensive. Employing a telemetry link instead of cables for data transmission, the system requires only battery powered transmitters with frangible antennas at the sides of the runway near each sensor. F.R.L.

**A71-23956** **The motion of incompressible fluids with electrical resistivity past thin airfoils in oblique fields.** Lazar Dragos (București, Universitatea, Bucharest, Rumania). *Zeitschrift für angewandte Mathematik und Physik*, vol. 22, Jan. 25, 1971, p. 96-108. 7 refs.

Reduction of the problem of electrically resisting fluid flow past a thin airfoil in the case of oblique fields to the solution of a Fredholm integral equation. The equation can be solved with the aid of the method of successive approximations. In the cases of aligned fields and perpendicular fields, for small magnetic Reynolds

numbers, the equations are solved explicitly and exactly. The lift is determined in the case of a flat plate, and the manner in which the lift decreases as the magnetic Reynolds number increases is shown. It is also shown that in the case of orthogonal fields the lift is smaller than in the case of aligned fields. The solution of classical aerodynamics is obtained from the general solution as a particular case, as well as the solution for a fluid with negligible resistivity.

A.B.K.

**A71-23957**      **An expansion method for boundary layers on thin airfoils.** Bernard Grossman and Stanley G. Rubin (Brooklyn, Polytechnic Institute, Farmingdale, N.Y.). *Zeitschrift für angewandte Mathematik und Physik*, vol. 22, Jan. 25, 1971, p. 109-130. 13 refs. Contract No. AF 49(638)-1623; Grant No. AF AFOSR 70-1843.

Development of a simple expansion method for investigating laminar incompressible boundary layers on thin airfoils. The proposed method combines an expansion for a small perturbation with 'quasi-similar' boundary layer theories. Various geometrical configurations are treated, including a Joukowski airfoil, a parabolic airfoil, and a slender wedge. The velocity profiles and friction values obtained are in good agreement with results from other sources, even for fairly thick airfoils. The method is regarded as particularly useful in the three-dimensional case, where other two-dimensional methods cannot be simply extended.

A.B.K.

**A71-23974 #**      **Instrumentation required for shuttle maintenance and operations.** John Bircham (British Aircraft Corp., Ltd., London, England). *American Institute of Aeronautics and Astronautics, Space Shuttle Development Testing and Operations Conference, Phoenix, Ariz., Mar. 15-17, 1971, Paper 71-313*. 9 p. Members, \$1.50; nonmembers, \$2.00.

This paper discusses the flight instrumentation requirements and concepts for the space shuttle vehicles. The space shuttle concept has many of the characteristics of a launcher, a spacecraft, and an airplane. The instrumentation will necessarily encompass all three of these flight modes. Additionally, during the development program, flight test instrumentation will supplement the operational installation. The operational equipment will include both real-time performance measurement and recorded and telemetered data for mission monitoring and maintenance. The emphasis in this paper is placed on concepts of data gathering, presentation of the information, recording and telemetry of useful data, using a digital data bus. The test and equipment status monitoring philosophies are also discussed.

(Author)

**A71-23982**      **Technology and market structure: A study of the aircraft industry.** Almarin Phillips (Pennsylvania, University, Philadelphia, Pa.). Lexington, Mass., D. C. Heath and Co., 1971. 236 p. \$12.50.

An important influence on market structures and on the research and development programs and innovative behavior of firms stems from the presence or absence of related technological and scientific changes which occur for reasons generally exogenous to market phenomena and the goals of particular firms. The argument is that a basic element causing the structural changes in the commercial aircraft industry was a scientific and technological environment which was itself changing. The structure of the market for commercial aircraft and the relations between operating costs and aircraft technologies, and the aggregate market for trunk line commercial aircraft are considered. Cost comparisons of successful and unsuccessful aircraft are made, and reasons for success or failure are suggested. Five appendixes provide tables of domestic airlines entering scheduled service, the characteristics of commercial aircraft, aircraft in the aggregate fleet of trunk airlines, and aircraft in fleets of individual carriers by carriers and by aircraft.

F.R.L.

**A71-24000**      **Unsteady air flow between two discs at low velocity.** C. E. Garcia (LTV Aerospace Corp., Las Cruces, N. Mex.). *Institution of Mechanical Engineers, Proceedings*, vol. 184, pt. 1, no.

48, 1969-1970, p. 913-923; Communications, p. 924, 925; Author's Reply, p. 926. 20 refs.

Velocities of air flowing between two discs were measured with a hot-wire anemometer where flow was induced with a steam ejector. Inward and outward flow were found to be unsteady, but outward flow unsteadiness was greater. This is due to the diffusion nature of the flow. A solution to the cylindrical wave equation was obtained and showed that, within the assumptions of the equation, a steady radial flow field becomes unstable upon passage of a wave due to a step function change of velocity at the boundaries of the flow. Comparison of a power spectrum of recorded data with one of turbulent air flow in a pipe showed the oscillations to be dissimilar. Unsteady motions seen in other studies of radial flow are also discussed.

(Author)

**A71-24011 #**      **Fundamentals of the theory of electric space propulsion systems (Osnovy teorii kosmicheskikh elektro-reaktivnykh dvigatel'nykh ustanovok).** O. N. Favorskii, V. V. Fishgoit, and E. I. Iantovskii. Moscow, Izdatel'stvo Vysshaya Shkola, 1970. 488 p. 167 refs. In Russian.

The physical foundations, principles of operation, characteristics, and mathematical foundations of advanced space propulsion systems are examined. The discussion includes heat-transfer and electric-arc type heat engines, ion engines, electromagnetic plasma engines, thermionic engines, nuclear energy sources, propulsion systems employing steam- and gas-turbine generators, systems employing closed-cycle reciprocating engines, thermoelectric generators, MHD and MGD generators, electrogasdynamic generators, and photoelectric generators. Characteristic cases of heat transfer in solids with internal heat release, the calculation of MHD and coolant flow parameters, the calculation of solar cells, and the selection of heat-transfer agents for closed-circuit systems are examined. The monograph is intended to serve as a textbook for advanced students, but should also be of interest to scientists and engineers.

V.P.

**A71-24012 #**      **Preliminary design of an aircraft (Eskiznoe proektirovanie samoleta).** B. T. Goroshchanko, A. A. D'iachenko, and N. N. Fadeev. Moscow, Izdatel'stvo Mashinostroenie, 1970. 332 p. 35 refs. In Russian.

Steps to be taken in preparing preliminary design specifications for aircraft are outlined. The main functions considered include (1) the definition of operational requirements to be used as performance and efficiency criteria, (2) calculation of the flight characteristics and structural parameters affecting aerodynamic stability, and (3) specification of the basic weight, geometrical, and structural aspects of the aircraft. Methods of arriving at tradeoffs in operational requirements are outlined, and examples are given which illustrate the determination of factors affecting the required speed, altitude, range, takeoff, landing, stability, and maneuverability. The selection of a particular configuration is explained, together with methods for specifying weight distributions, propulsion systems, fuselage assemblies, tail structures, wing arrangements, and cabin areas.

T.M.

**A71-24013 #**      **Flight of an aircraft with incomplete and asymmetrical thrust (Polet samoleta s nepolnoi i nesimmetrichnoi tiagoi).** M. L. Gallai. Moscow, Izdatel'stvo Mashinostroenie, 1970. 192 p. 23 refs. In Russian.

Problems concerning the dynamics of a multiengine aircraft immediately after the failure of one of the engines are examined. Attention is given to the probabilistic characteristics of such a flight, the effects of external factors and of the aircraft's aerodynamic parameters, stabilized on-course flight, landing approach, landing, and takeoff with partial engine failure. Special attention is given to the explanation of physical mechanisms responsible for the effects experienced during flight with incomplete and asymmetrical thrust. Practical recommendations are directed at both aircraft designers and pilots, providing information about structural solutions to eliminate possible emergencies and optimal piloting procedures to cope with engine failure. A separate section discusses international and regional certification standards for aircraft characteristics in case of power failure.

T.M.

**A71-24064**      **New directions in aircraft adhesives and sand-wich structural materials.** Andre B. Kerr (Furane Plastics, Inc., Los Angeles, Calif.). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings.

Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings. Volume 2), 1970, p. 1-8.

Description of two-component, high peel strength epoxy and urethane adhesives for aircraft bonding operations. New room temperature curing systems which offer good properties at elevated temperatures are also presented. Repair procedures for honeycomb panels are discussed. Z.W.

**A71-24069**      **A tough, moderately heat resistant, room temperature curing structural adhesive.** Malcolm E. Gross (B. F. Goodrich Co., Brecksville, Ohio). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings.

Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings. Volume 2), 1970, p. 49-61. 5 refs.

Description of a room temperature curing adhesive for bonding rigid composite structures containing elements with widely divergent coefficients of thermal expansion. This adhesive combines toughness and good shear strength in the medium temperature range of 200 F. It is based upon a prereaction product between a low molecular weight epoxy resin and a liquid nitrile copolymer having terminal group reactivity. The adhesive was used successfully for bonding fiber-reinforced plastics to metal substructures for service use in a temperature range from -20 to 250 F. Z.W.

**A71-24079**      **Self-sealing aircraft fuel tanks.** William F. Anspach (USAF, Materials Laboratory, Wright-Patterson AFB, Ohio). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings.

Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings. Volume 2), 1970, p. 167-174.

The role and importance of the damage control material, self-sealing material, and fuel barrier in the overall self-sealing system are discussed. Both self-sealing integral fuel tanks and self-sealing fuel cells are examined. The following self-sealing concepts are considered: chemical systems, fuel sensitive layers (elastomers which swell), precompressed foams, reactive chemical systems, and elastomeric spheres. In this last concept when the system is punctured, the balls flow to the wound, plug it, and swell to seal it. Z.W.

**A71-24080**      **Fluorosilicone fuel containment sealants.** J. K. Wessel (Dow Corning Corp., Midland, Mich.). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings.

Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings. Volume 2), 1970, p. 175-181.

Fuel tank sealants of today's aircraft must withstand new levels of heat and heat aging. At the same time, they must resist jet fuel, moisture, and they should not become brittle at low temperatures. Fluorosilicone sealants of various types are meeting these needs. Flexible bead formulations developed recently by McDonnell-Douglas engineers show promise of making these sealants even more reliable. (Author)

**A71-24081**      **Recent developments in high-temperature aircraft fuel-tank sealants.** Lester Morris (Products Research and Chemical Corp., Burbank, Calif.). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers,

National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings. Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings. Volume 2), 1970, p. 183-190.

Three types of sealant products are described for high-temperature fuel exposures on aircraft. They differ in polymer type and performance range. A polysulfide-based material is evaluated for 350 F performance. A second sealant with long-term 450 F capabilities based on a new, low-temperature fluorocarbon elastomer is described. A third product with potential value for high-temperature 'groove injection' sealing based upon a modified polysiloxane is also presented. (Author)

**A71-24083**      **Accelerated testing of fuel containment sealants.** Gary Snyder, Edward Sweet, and Thomas Talcott (Dow Corning Corp., Midland, Mich.). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings.

Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings. Volume 2), 1970, p. 199-208.

Development of an accelerated fuel containment sealant test procedure using a reduced pressure, jet fuel vapor environment at temperatures between 525 and 600 F. The data supporting the validity of accelerable testing were generated in tests using a new hybrid fluorocarbon/silicone sealant as a test material. (Author)

**A71-24084**      **Optimum weight bonded structure design using variable weight composite materials.** L. E. Meade. In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings. Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings. Volume 2), 1970, p. 209-220.

Using the C-5A aircraft as an example, it is shown how weight was saved by selecting the optimum weight materials for each adhesive design. The selection of an adhesive weighing 0.045 lb/sq ft instead of one weighing 0.060 lb/sq ft saved 640 pounds of the originally anticipated weight. In approximately 40% of the C-5A honeycomb applications, 5/32 in. cell size, 0.0007 in. nominal foil gauge core, having a density of 2.6 lb/cu ft, was found to be suitable for face sheet stabilization instead of the 1/8 in. cell size. This accounted for an additional 400 pounds of weight saved. Z.W.

**A71-24093**      **Structural bonding of titanium for advanced aircraft.** Robert E. Walter, David L. Voss, and Marvin S. Hochberg (McDonnell Aircraft Co., St. Louis, Mo.). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings.

Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings. Volume 2), 1970, p. 321-330.

Annealed Ti-6Al-4V, annealed Ti-6Al-6V-2Sn, and heat treated and aged Ti-6Al-6V-2Sn alloys were used to determine the effect of alloy and heat treatment on the bondability of Ti. Supported and modified epoxy adhesives, Metlbond 329.HT424, Scotchweld AF 131HP and Plastilock 677, were evaluated for bonding Ti skins to Al and phenolic fiber glass honeycomb core. Unsupported nitrile-phenolic adhesives, AF 31 and Plastilock, were evaluated for Ti-to-Ti joints. Nonperforated 5056-H39 aluminum and heat resistant phenolic glass fabric were evaluated as honeycomb core materials for applications at 450 F under cyclic loading. Duracore and corrosion inhibiting adhesive primers were evaluated to obtain corrosion resistant adhesively bonded structures. Metal-to-metal evaluation tests for lap shear and T-peel and skin-to-honeycomb tests for flatwise tension, climbing drum peel, short column compression, longitudinal beam shear, thermal gradient, and fatigue were con-

ducted to obtain data for applications on advanced fighter aircraft. Prebonding cleaning of Ti by 30-sec immersion at 70 F in 10% hydrofluorosilicic acid provided acceptable lap shear strength in specimens after 96 hr storing, comparing favorably with other cleaning techniques. V.Z.

**A71-24096 Contoured silicone pressure mandrels for fabrication of helicopter rotor blades.** A. E. Holt and J. H. Powell (Bell Helicopter Co., Fort Worth, Tex.). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings. Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings, Volume 2), 1970, p. 353-361.

Recent advancements in rotor blade designs have posed new problems in their fabrication and bonding. To solve these problems, internal pressure bag mandrels were devised, using silicone elastomers and/or foams. The mandrels are: rigid enough to locate and support blade parts, elastic enough to apply even pressure during bonding, able to withstand 350 F repeatedly, self releasing, and collapsible for removal from openings of half the mandrel's size. The mandrel's fabrication techniques and use in rotor blade fabrication are discussed. (Author)

**A71-24101 Polyurethane coatings for subsonic rain erosion protection.** J. F. Moraveck (Olin Corp., New Haven, Conn.). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings. Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings, Volume 2), 1970, p. 425-439. Contracts No. AF 33(615)-68-C-1068; No. AF 33(615)-A-3633.

A whirling arm apparatus using a simulated rainfall proved invaluable in the development of erosion-resistant polyurethane coatings. Polyurethanes with widely different physical properties were synthesized and tested extensively in rain in an attempt to correlate structure and physical properties to dynamic performance. Further, these tests showed that coating performance and modes of failure of a particular formulation was also dependent upon the substrate construction, primer used and coating thickness. (Author)

**A71-24102 Photochromic coatings for nondestructive testing.** Sidney Allinikov and Albert Olevitch (USAF, Materials Laboratory, Wright-Patterson AFB, Ohio). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings. Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings, Volume 2), 1970, p. 441-460.

This paper describes the development and application of a photochromic paint to nondestructively inspect aerospace materials and structures. The formulation of the paint is described as well as the methods of application of the paint. The paint is converted from a white to a bright violet color by exposure for a few seconds to ultraviolet light. The painted surface is heated by any suitable means such as a hot air blower. The heat bleaches the paint to its original white color. If defects are present the conductivity at the site of the defect is different from that of the rest of the area inspected. The defect is thus visualized as a colored or white area depending on the nature of the defect. The paper discusses the types of defects and the kinds of structures to which this special paint can be used. The advantages and limitations are also pointed out. (Author)

**A71-24103 Density gradient visualization with a schlieren optical system.** Robert M. Wohlfed (Bell Helicopter Co., Fort Worth,

Tex.). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings.

Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings, Volume 2), 1970, p. 461-470. 5 refs.

This paper presents results of preliminary investigations of propeller aerodynamics using schlieren optical techniques. Although this paper deals mainly with aerodynamics it also discusses the manner in which a schlieren system can be used for nondestructive testing of polymers and adhesives. A ten minute movie shows the aerodynamic results as seen with a schlieren system. (Author)

**A71-24112 A comparative test for corrosion resistant adhesive primers.** Narvel L. Rogers (Bell Helicopter Co., Fort Worth, Tex.). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings. Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings, Volume 2), 1970, p. 571-588.

Improved corrosion resistance is an objective in all aircraft design. The advent of the corrosion inhibiting adhesive primers provides the designer with an additional tool to use in reaching this objective. As with any new material, tests must be developed that will provide some insight into the relative merits of the different adhesive systems. In that the end use of a material will vary with each designer, the technique of testing must vary to insure reliable and usable data. (Author)

**A71-24115 Hydrolytic stability of electrical potting compounds.** Philip A. House (USAF, Materials Laboratory, Wright-Patterson AFB, Ohio). In: Aerospace adhesives and elastomers; Society of Aerospace Material and Process Engineers, National Technical Conference, 2nd, Dallas, Tex., October 6-8, 1970, Proceedings. Azusa, Calif., Society of Aerospace Material and Process Engineers (National SAMPE Technical Conference Proceedings, Volume 2), 1970, p. 609-642.

Investigation of the resistance to reversion of plastics employed as potting compounds in aircraft electrical systems. Reversion was first observed in a polyester polyurethane potting compound on the F-4 aircraft as a result of poor hydrolytic stability of the compound. A program was conducted to determine the hydrolytic stability of all potting compounds used by the Air Force. The results of the test program are presented. O.H.

**A71-24150 # V/STOL area navigation.** J. C. Alexander and C. L. Heide (Computing Devices of Canada, Ltd., Ottawa, Canada). (Canadian Aeronautics and Space Institute, Aerospace Electronics Symposium, Ottawa, Canada, Mar. 19, 20, 1970.) *Canadian Aeronautics and Space Journal*, vol. 17, Mar. 1971, p. 89-93. 11 refs.

Discussion of area navigation system requirements of commercial V/STOL aircraft. The solutions to the navigation problems in the congested air environment to be derived from the airborne computer, flight plan data storage and control subsystems, and horizontal orientation display, to make up the V/STOL area navigation system hardware, are reviewed. The hardware development work currently in progress is described. M.V.E.

**A71-24158 # Investigation of aircraft motion and traffic control processes under conditions of random disturbances (Issledovanie protsessov dvizheniya i upravleniya samoletopotokami v usloviyakh sluchainykh vozmushchenii).** E. V. Melikhova. In: Current problems of cybernetics (Sovremennyye problemy kibernetiki). (A71-24155 10-10) Edited by Ia. Z. Tsyppin. Moscow, Izdatel'stvo Nauka, 1970, p. 70-76. In Russian.

## A71-24174

The flight dispatching problem in air traffic control is examined from the viewpoint of obtaining a control quality criterion. Safety restrictions limit the region of admissible solutions, and the dispatcher strives toward a minimum of deviations from the initial flight schedule to satisfy economic requirements while maintaining flight safety. Statistical simulation is used to determine the weighting coefficients of control parameters, and attention is given to the possibility of traffic rate control that maintains schedules with allowance for random factors associated with weather conditions. Traffic flow at intersections of air corridors is analyzed, and the effects of random factors on flight in these areas are evaluated. T.M.

**A71-24174 # The need for developing a high Reynolds number transonic wind tunnel in the U.S.** Julius Lukasiewicz (Carleton University, Ottawa, Canada). *Astronautics and Aeronautics*, vol. 9, Apr. 1971, p. 64-70.

Study of the growing gap between the Reynolds numbers of actual transonic flight and those achieved in wind tunnel simulations in the U.S., considering this gap as a possible cause of unpredicted aircraft flight and rocket trajectory situations. The effects of Reynolds numbers on maximum low-speed lift and wing section pitching moment are analyzed. Shock-induced flow separations in a wind tunnel and during a full-scale flight are compared. The performances and designs of the Ludwig tube tunnel and the blowdown tunnel are discussed. It is urged that the technique of transonic testing at high lift conditions should be developed further. V.Z.

**A71-24175 VHF over-the-horizon ground-to-air communication equipment.** Itsugo Takeishi, Tsugio Sudo, and Rokuro Shimada (Tokyo Shibaura Electric Co., Ltd., Tokyo, Japan). *Toshiba Review*, Feb. 1971, p. 22-28.

Description of the design and operation of the communication equipment of the first regular air traffic control station constructed in Japan for communication with the Northern Pacific air routes. The equipment consists of one high-gain antenna (25.5 dB), two VHF AM transmitters (carrier power 2 kW), three low-noise VHF over-the-horizon receivers with 3-dB noise figure, and three terminal supervisory units for controlling and monitoring the transmitters and receivers and for receiving the transmission and reception voice signals. The results of actual contact with an airplane in flight have demonstrated that the communication range is up to 377 nm, which is nearly identical with the theoretical value. O.H.

**A71-24215 Advanced centrifugal compressors.** New York, American Society of Mechanical Engineers, 1971. 221 p. Members, \$12.60; nonmembers, \$15.75.

Topics include aspects of fluid dynamics of the centrifugal compressor, and an investigation conducted to develop a small, high-pressure-ratio radial compressor. Performance and problems of single-stage compressors with pressure ratios in the range 10:1 to 15:1 are considered, as well as research undertaken to define design criteria and performance characteristics. G.R.

**A71-24216 On the unresolved fluid dynamics of the centrifugal compressor.** Robert C. Dean, Jr. (Creare, Inc., Dartmouth College, Hanover, N.H.). In: *Advanced centrifugal compressors*. New York, American Society of Mechanical Engineers, 1971, p. 1-55. 54 refs.

The fluid dynamics of the centrifugal compressor are surveyed with particular emphasis on those aspects not perfectly understood. Among all turbomachines, the radial compressor and turbine are unique because the details of their flows are still in large part unknown. In contrast, the axial compressor and turbine have only a few important mysteries remaining. The intent of this paper is to sketch out the uncharted territory with the expectation that this exploration may encourage appropriate research upon the critical problems and the development of realistic design systems. Data are included to emphasize the significance of various phenomena. The

crucial fluid dynamic aspects of the centrifugal compressor are identified tentatively. Forecasts of ultimate performance are then offered. The future of the centrifugal compressor appears to be bright, provided that its complicated fluid dynamics can be unscrambled and mastered for design optimization. (Author)

**A71-24217 The radial outflow compressor.** J. R. Erwin and N. G. Vitale (General Electric Co., Evendale, Ohio). In: *Advanced centrifugal compressors*. New York, American Society of Mechanical Engineers, 1971, p. 56-117. 22 refs. Contract No. DA-44-177-AMC-180(T).

Aerodynamic and mechanical compressor analyses are described, and aerodynamic cascade tests, low-speed compressor tests, mechanical bench tests, and design studies which led to the construction of a high-speed compressor are discussed. An account of developmental testing of the high-speed compressor leading to further improvements is given. The improved compressor performance is achieved by eliminating the inlet guide vane system, including a circular inlet turning vane, enlarging the exit scroll, using new rotor blades, and employing subsonic stator vanes. G.R.

**A71-24218 High pressure ratio centrifugal compressors for small gas turbine engines.** R. E. Morris and D. P. Kenny (United Aircraft of Canada, Ltd., Longueuil, Quebec, Canada). In: *Advanced centrifugal compressors*. New York, American Society of Mechanical Engineers, 1971, p. 118-146. 10 refs. Research supported by the Defence Research Board of Canada and United Aircraft of Canada.

It is pointed out that poor specific fuel consumption of the gas turbine has been a major factor in preventing its general use. The variation of specific fuel consumption and specific power with cycle pressure ratio and turbine inlet temperature is investigated, and some data on the performance of single stage centrifugal compressors with pressure ratios in the range 10:1 to 15:1 are presented. It is found that a major problem with high pressure ratio compressors is the avoidance of separation within the impeller. Research impellers which have been designed initially by a relatively simple potential flow method are described. Loading diagrams are evaluated by a novel pipe analogy method. A novel diffuser capable of accepting the nonuniform supersonic flow from the impeller with low loss and good operating range is discussed. G.R.

**A71-24219 Design and development of small, high pressure ratio, single-stage centrifugal compressors.** P. G. Schorr, A. D. Welliver, and L. J. Winslow (Boeing Co., Seattle, Wash.). In: *Advanced centrifugal compressors*. New York, American Society of Mechanical Engineers, 1971, p. 147-217. 23 refs.

Studies of Boeing compressor designs in the pressure ratio range of 3.5:1 to 6:1 form the background of the work discussed. An account is given of a number of tests conducted with the impeller and diffusers in order to obtain overall compressor maps. The overall performance target was a pressure ratio of 10:1 at an adiabatic efficiency of 80% at an airflow of 2 lb/sec. The maximum compressor pressure ratio (static to total) measured was 10.6:1 (106% design speed). Airflow range up to 16% was demonstrated at pressure ratios between 9.0 and 10.0:1. Compressor adiabatic efficiency of 72.0% was nearly constant at all compressor speeds. G.R.

**A71-24239 Development of a single-grade general aviation avgas.** H. J. Foster and L. G. Olson (Shell Oil Co., Houston, Tex.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710369*. 14 p. Members, \$1.00; nonmembers, \$1.50.

To verify the practicality of a single-grade general aviation avgas which would meet the needs of engines using grade 80/87 and 100/130 fuel, a flight evaluation was conducted in selected light aircraft. Some 2200 hr of actual flight operation demonstrated the

acceptability of this fuel for grade 80/87 certificated aircraft, together with a performance advantage for grade 100/130 users.

(Author)

**A71-24240 Aircraft carburetor icing studies.** L. Gardner, G. Moon, and R. B. Whyte (National Research Council, Fuels and Lubricants Laboratory, Canada). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710371.* 10 p. 8 refs. Members, \$1.00; nonmembers, \$1.50.

A study has been made of the effect of gasoline icing inhibitors on aircraft carburetor icing. An engine test was developed and used to evaluate various types of inhibitor. The results obtained showed that aircraft carburetor icing can be prevented by the inclusion of additives in the gasoline. The use of a Teflon-coated throttle plate to prevent ice adhesion was studied, and it was found that virtually all ice formation on the plate was eliminated. The Teflon-coated plate and the use of ethylene glycol monomethyl ether at 0.10-0.15% by volume in the gasoline were shown to prevent both carburetor and fuel system icing.

(Author)

**A71-24241 The FAA flying and handling qualities program.** Jerome Teplitz (FAA, Washington, D.C.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710372.* 4 p. Members, \$1.00; nonmembers, \$1.50.

Discussion of the efforts being made to correlate aircraft stability and control requirements. Presented are principal features of the FAA flying and handling qualities program, the objective of which is the development of flight characteristics criteria, quantified when possible and intended to define both optimum and minimum acceptable characteristics for use in the design of new aircraft, both civilian and military.

O.H.

**A71-24242 Flying qualities criteria for small general aviation airplanes as determined by in-flight simulation.** David R. Ellis (Princeton University, Princeton, N.J.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710373.* 7 p. 5 refs. Members, \$1.00; nonmembers, \$1.50.

In-flight simulation techniques using a variable-stability airplane have been used to determine quantitative flying qualities criteria for small general aviation aircraft. Recent experiments covering longitudinal short-period frequency and damping, pitch control sensitivity, and lift-curve slope indicate that the combination of parameters giving the best level of flying qualities can be identified, but reasonably wide variations are possible without causing serious degradation. Instrument approaches can be successfully flown with moderate levels of static instability, but even small instabilities may be undesirable due to the danger of upsets following pilot distraction.

(Author)

**A71-24243 Lateral-directional handling qualities for the executive jet in the landing approach.** G. Warren Hall (Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710374.* 7 p. Members, \$1.00; nonmembers, \$1.50. Contract No. AF 33(615)-69-C-1664.

Lateral-directional handling qualities for executive jet and related medium weight airplanes in the landing approach flight phase were investigated in the USAF/CAL variable stability T-33 airplane. Emphasis was placed on the effects of crosswinds and turbulence. Simulated IFR ILS approaches and VFR offset and crosswind approaches were made. Specifically, two Dutch roll frequencies, three Dutch roll damping ratios, three roll-to-sideslip ratios, and three roll mode time constants were investigated. It was found that the ranges of lateral-directional dynamics investigated do not establish a limiting crosswind value; however, they do determine the ease or difficulty with which a crosswind approach can be accomplished. Roll control power requirements were determined from pilot

control usage data and an investigation of the effects of limited roll control power. It was found that available roll control power can establish a limiting crosswind component.

(Author)

**A71-24244 \* NASA aerodynamic research applicable to business aircraft.** Laurence K. Loftin, Jr. and Marion O. McKinney, Jr. (NASA, Langley Research Center, Hampton, Va.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710378.* 11 p. 9 refs. Members, \$1.00; nonmembers, \$1.50.

A review is made of NASA aerodynamic research of interest to the designer of business aircraft. The results of wind-tunnel and flight studies of several current aircraft are summarized. The attainment of STOL performance is discussed and the effectiveness of several lift augmentation concepts is examined. Finally, the potentialities and problems of flight at and beyond the speed of sound are discussed.

(Author)

**A71-24245 \* The turn rate indicator - Its interpretation as affected by installation and true airspeed.** G. W. Stinnett, C. T. Jackson, Jr., and P. D. Talbot (NASA, Ames Research Center, Moffett Field, Calif.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710380.* 6 p. Members, \$1.00; nonmembers, \$1.50.

The effects of mounting an airplane turn rate gyro at various angles relative to the roll axis of the vehicle have been investigated in flight. The range of suitable mounting angles varies not only with the amount of roll rate sensing desired for lead information, but also with the true airspeed of the airplane. Tilting the gyro in a face-up direction, as occasionally happens on a slightly inclined instrument panel, might have disastrous results if the instrument is relied on for recovery from an unusual attitude. Turn rate information is of very limited value on airplanes having high subsonic cruise speed.

(Author)

**A71-24246 Time between overhaul as related to modern engine design and maintenance techniques.** R. B. Ingram (Avco Corp., Avco Lycoming Div., Stratford, Conn.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710381.* 10 p. Members, \$1.00; nonmembers, \$1.50.

Discussion of extended time between overhauls (TBO) programs in the aircraft industry. TBOs of above 2000 hr for certain Lycoming aircooled aircraft piston engines are shown to be practical through the use of modern engine design, materials, and maintenance technology. Several examples of extended time programs are shown for a 150 bhp direct drive, 4-cylinder engine and 380 bhp 6-cylinder geared and 310 bhp turbocharged engines. Limiting TBO factors and practical limits of TBO are also discussed.

O.H.

**A71-24247 Development of a dual ignition system for general aircraft.** Richard P. McClelland (Bendix Corp., Electrical Components Div., Sidney, N.Y.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710382.* 6 p. Members, \$1.00; nonmembers, \$1.50.

A new dual magneto has been developed for use on engines in business and small military aircraft. This ignition system represents a considerable advance in the areas of weight saving, ease of installation, maintainability, and synchronization of the two sparks in each cylinder. This paper describes the reasons for its development, design details, and the test program followed in its development. It includes a discussion of the problems encountered during testing and the natures of their solutions.

(Author)

**A71-24248 General aviation engine oil filtration - A model specification.** William M. Paradise (Champion Spark Plug Co., Toledo, Ohio) and H. C. Mouwen (PurOlator, Inc., Newbury Park, Calif.). *Society of Automotive Engineers, National Business Aircraft*

## A71-24249

Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710383. 8 p. 6 refs. Members, \$1.00; nonmembers, \$1.50.

Model design and performance specification for filters used in general aviation engine lube oil systems. Filter types are classified, their construction is described, and some of the popular filter applications are reviewed. A model specification is presented which concerns the filter assembly to ensure its improved efficiency, greater dirt-holding capacities, and reliable mechanical integrity. O.H.

**A71-24249 Noise certification of business jet aircraft.** William J. Galloway (Bolt Beranek and Newman, Inc., Cambridge, Mass.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710384.* 7 p. Members, \$1.00; nonmembers, \$1.50.

Noise certification under FAR Part 36 is now a requirement for issuance of all new and supplemental type certificates for turbojet-powered or transport-category aircraft. Recent experience with three noise certification programs has shown: how to estimate from aircraft performance data the necessity and extent of noise measurement requirements, ways to show compliance through the use of equivalent test data, and techniques for minimizing program cost.

(Author)

**A71-24250 Engine nacelle noise prediction and trades.** Henry F. Veldman (Boeing Co., Wichita, Kan.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710386.* 7 p. 6 refs. Members, \$1.00; nonmembers, \$1.50.

The object of engine nacelle noise prediction is to use aircraft sound data measured at a test site or measured from flyover data and estimate the noise level as a function of time at other hypothetical observer locations. The simulation consists of applying attenuation corrections to the input sound pressure spectra to obtain the projected spectra as a function of time. The effect of acoustic noise suppression can be analyzed by examining the influence of each noise source on the total noise spectra. Trade studies can be conducted by constructing lines of constant annoyance for aircraft landing, takeoff, or fly-by.

(Author)

**A71-24251 \* The application of spoilers to a small, fixed-wing general aviation aircraft.** John W. Olcott (Aeronautical Research Associates of Princeton, Inc., Princeton, N.J.), David R. Ellis (Aeronautical Research Associates of Princeton, Inc.; Princeton University, Princeton, N.J.), and Alan E. Fayé (NASA, Ames Research Center, Moffett Field, Calif.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710387.* 16 p. 6 refs. Members, \$1.00; nonmembers, \$1.50.

Flight tests were made of spoilers/dive brakes on small fixed-wing aircraft to investigate whether such aerodynamic surfaces could be used to augment the glide path performance and longitudinal handling qualities of such aircraft in a manner which would be beneficial during the total landing risk. Steady state flight path angles up to 13 deg for a true airspeed of 85 mph were obtained with a spoiler/dive brake area of 5.7 sq ft. No change in trim airspeed was experienced for that configuration provided 15 deg of flaps were used. An 11.92 sq ft spoiler/dive brake configuration produced steady state flight path angles up to 18 deg at 90 mph true airspeed. Preliminary evaluations indicated that the former configuration offered significant improvements in the vehicle's handling qualities during the total landing risk, provided a suitable means of controlling the considerable performance of the spoilers/dive brakes was available.

O.H.

**A71-24252 The influence of bobweights and downsprings on flying qualities.** T. Peter Neal (Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710388.* 9 p. 5 refs. Members, \$1.00; nonmembers, \$1.50.

Control-system bobweights and downsprings are quite often

used in general aviation airplanes to improve longitudinal static stability at aft c.g. positions. However, these devices can also have strong and usually undesirable effects on the airplane's dynamic behavior. These important effects are reviewed and discussed. In addition, guidance is provided as to how some of the undesirable characteristics can be minimized by careful design. (Author)

**A71-24253 Low speed airfoil analysis using a small digital computer.** W. H. Wentz, Jr. (Wichita State University, Wichita, Kan.), J. A. Miller (Boeing Co., Seattle, Wash.), and R. E. Koepsel (Kiekhäfer Mercury Corp.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710389.* 7 p. 12 refs. Members, \$1.00; nonmembers, \$1.50.

A computing routine has been developed for calculation of two-dimensional incompressible airfoil characteristics on a small (IBM 1130) digital computer. Theodorsen's method of conformal transformation is utilized to obtain potential flow pressure distributions. A selection of quadrature methods are utilized to obtain boundary layer characteristics, including laminar and turbulent layers, instability transition, and separation. Selected results are presented which illustrate the capabilities and limitations of the program. Typical computing times and costs are presented. Several suggested improvements to the calculation routine are discussed.

(Author)

**A71-24254 Chemical oxygen generators for business and utility aircraft.** V. N. Harwood (Automatic Sprinkler Corporation of America, Scott Aviation Div.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710390.* 10 p. Members, \$1.00; nonmembers, \$1.50.

New FAA Oxygen Requirements Standards state that emergency supplemental oxygen is a necessity in any pressurized aircraft flying over 25,000 ft. Chemical oxygen generators can be used to fulfill the new requirements. They offer savings in weight, size, and maintenance, while offering considerably greater safety. The oxygen generator packages, which offer variations of function and size, are discussed.

(Author)

**A71-24255 Air conditioning the Piper Cherokee product line.** J. L. Jiruska (Piper Aircraft Corp., Lock Haven, Pa.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710391.* 9 p. Members, \$1.00; nonmembers, \$1.50.

For many years, the designers of general aviation light aircraft have been more preoccupied with safety and performance than comfort. In order to expand the user base and utility of the small airplane, we must provide the elementary comforts which we have come to demand from our automobiles. We are currently working to improve sound levels, seating comfort, ventilation, and other human factors; now we must air condition. This paper will not deal with the basics of refrigeration system design as many books are available on this subject. We will touch briefly on a review of system theory and types, then take you through the conceptual thinking, design considerations, certification, and service test phases of our program.

(Author)

**A71-24256 Optimizing the design of the battery-starter/generator system.** John M. Evjen and Lawrence D. Miller, Jr. (General Electric Co., New York, N.Y.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710392.* 10 p. Members, \$1.00; nonmembers, \$1.50.

Aircraft starting and generating systems heretofore have been largely the result of joining together available components. Recent studies have demonstrated that substantial benefits in weight, cost, size, and performance may be realized through a total system approach. This paper identifies the types of information required, and the methods of system analysis employed, to design an optimized system.

(Author)

**A71-24257 \*** **A flight control system providing a simple-to-fly, constant attitude aircraft.** Frederick O. Smetana (North Carolina State University, Raleigh, N.C.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710393.* 10 p. Members, \$1.00; nonmembers, \$1.50. NASA-supported research.

Most light aircraft accidents occur during landing and takeoff because at these times the pilot must operate controls frequently and precisely and with more than average force. These operations are further complicated by the nose-high attitude of the aircraft, which interferes with a normal visual control reference. The purpose of the studies reported here was to design an aircraft that would fly at zero pitch angle and would require a minimum of pilot commands for satisfactory operation. Preliminary investigation showed that it would be possible to modify an existing airplane by providing a three-component control system, new wing with Fowler flaps for lift modulation, and additional longitudinal control power. The details of these modifications are described fully in this paper. (Author)

**A71-24258** **Qualification of light aircraft for flight in icing conditions.** Paul R. Leckman (Cessna Aircraft Co., Commercial Aircraft Div., Wichita, Kan.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710394.* 24 p. 15 refs. Members, \$1.00; nonmembers, \$1.50.

Since light aircraft are being used more and more frequently in the IFM environment, icing is becoming a greater operational problem. This paper reviews the icing problem for light aircraft. Design criteria and flight testing techniques are discussed. The discussion is limited to general aviation aircraft whose maximum takeoff gross weight is less than 6000 lb. Both theoretical and flight test data are reviewed. Data are included which describe the increase in instrument-rated pilots and IFR flying activity in recent years. Flight profiles of a typical light aircraft are compared with larger aircraft. Performance penalties due to ice accumulations are presented for light aircraft based on flight test experience to date at the Commercial Aircraft Div. of Cessna Aircraft Co. (Author)

**A71-24261** **Crash injury severity as related to aircraft attitude during impact.** Terry F. Wallace and John J. Swearingen (FAA, Protection and Survival Laboratory). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710399.* 7 p. Members, \$1.00; nonmembers, \$1.50.

A small number of general aviation aircraft accidents selected from the files of the Civil Aeromedical Institute illustrate potential injury severity in various crash situations. It appears that crash injuries, especially to the head and chest, are apt to be more severe in aircraft involved in forward, right side up crash decelerations in which the occupants are restrained by seat belts only. Minor injury, severe crashes are described in which the principle crash forces were: to the side, forward with the aircraft inverted, or forward with the aircraft right side up but with the occupants utilizing both seat belt and shoulder harness restraint. Apparently to avoid serious injury in general aviation crash impacts, one must avoid striking the rigid, nonpadded instrument panel. In addition, a single case is presented to illustrate the high probability of injury to the spine and internal organs in present-day aircraft when the principle crash forces are vertical. (Author)

**A71-24262** **Structural considerations of steel landing gear springs.** Don McCosh (Cessna Aircraft Co., Commercial Aircraft Div., Wichita, Kan.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710400.* 12 p. 6 refs. Members, \$1.00; nonmembers, \$1.50.

Aircraft produced by Cessna have, for a number of years, used steel landing gear springs as the major portion of the aircraft main or tail landing gears. These steel springs are relatively simple in design and manufacture, and have proved to be durable. This paper discusses some of the factors involved in the design of a spring steel landing gear, analysis methods, and design goals used at Cessna. Certification requirements and methods of compliance for landing

gears are also discussed. The analysis methods employed have been proved acceptable by the ability of the gears to pass certification tests without modification, and by service experience. (Author)

**A71-24263** **Analytical simulation of landing gear dynamics for aircraft design and analysis.** J. F. Furnish and D. E. Anders (Cessna Aircraft Co., Military and Twin Div., Wichita, Kan.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710401.* 9 p. 7 refs. Members, \$1.00; nonmembers, \$1.50.

This paper presents an analysis of a nonlinear landing gear mounted on a flexible airplane equipped with external stores and tip tanks. Interaction effects of the flexible airplane with the gear are included. The method of treating the strut lockup-breakout phenomena is an improvement over previous work. Test results are presented from a full scale test of an airplane supported on displacement controlled hydraulic actuators, which simulated taxiing over discrete runway bumps. The analytical method was applied to several design problems which are also discussed. (Author)

**A71-24264** **Fatigue substantiation procedures for general aviation aircraft.** Arnold E. Anderjaska (FAA, Flight Standards Service, Washington, D.C.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710404.* 27 p. 9 refs. Members, \$1.00; nonmembers, \$1.50.

Fatigue substantiation of wing structure on small airplanes is now required by the Federal Aviation Regulations for civil type certification of new designs. Methods for substantiation of this structure under the 'safe-life' concept, including suggested loading spectra and procedures for strength determination are outlined. The background leading to these methods and a basis for establishing scatter factors are presented. Procedures for substantiation under the 'fail-safe' concept are also given. (Author)

**A71-24265 #** **Relationship between the phenomenology of uncertainty and the degree of effectiveness in the future of the international air transportation industry (Rapporto tra fenomenologia dell'incertezza e grado di efficienza nel futuro dell'industria del trasporto aereo internazionale).** Gianrocco Tucci. *Istituto Internazionale delle Comunicazioni, Convegno Internazionale delle Comunicazioni, 18th, Genoa, Italy, Oct. 12-16, 1970, Paper.* 30 p. 8 refs. In Italian.

Discussion of factors of uncertainty in management decisions and the necessity for optimizing operations in the field of international air transports. The factors which affect the optimization of operations are extent of services produced and sold, price, and capital available for investment in corporate operations. It is pointed out that the present structure of the international air transport industry, which is not to be expected to vary substantially in the near future, will not lead to the discontinuance of price competition, hence the reduction of the uncertainty factors. Therefore, the reduction of the margin of uncertainty is to be sought in gaining greater knowledge of the services-producing function, in the modification of the corporate setup and/or change in the relationships between a company and its clients. M.M.

**A71-24270 #** **Interferometer and total pressure measurements in a supersonic boundary layer.** Luciano M. De Socio (Minnesota, University, Minneapolis, Minn.). *Istituto Internazionale delle Comunicazioni, Convegno Internazionale delle Comunicazioni, 18th, Genoa, Italy, Oct. 12-16, 1970, Paper.* 22 p. 8 refs.

The determination of the boundary layer density profile over a flat plate by means of a Mach-Zehnder interferometer is discussed. The determination was made on a turbulent boundary layer at a single Reynolds number. Aspects of experimental design are considered taking into account problems of interferometer adjustments and compensator rotation. The reduction of interferometer data and correction of errors is described. The data obtained were checked

against the density profile calculated from a total profile using the assumption of isoenergetic flow. G.R.

**A71-24271 # ATCAS, the Italian air traffic control automation system ('ATCAS,' sistema italiano di automazione del controllo del traffico aereo).** Paolo Regi (IBM Italia S.p.A., Milan, Italy). *Istituto Internazionale delle Comunicazioni, Convegno Internazionale delle Comunicazioni, 18th, Genoa, Italy, Oct. 12-16, 1970, Paper. 18 p.* In Italian.

The design of ATCAS is the outcome of thorough studies initiated in 1963 by experts of IBM-Italia and Selenia. The main functions of ATCAS are: (1) to relieve the controller as much as possible from tasks of an executional nature in order to increase his available time for the performance of conceptual tasks (decisional evaluations); and (2) to automate as much as possible conceptual functions by supplying the controller with solutions to the principal ATC problems. Selenia, as the prime contractor, is responsible for the system. M.M.

**A71-24274 # V/STOL systems as a unifying factor in transport.** I. C. Cheeseman (Southampton, University, Southampton, England). *Istituto Internazionale delle Comunicazioni, Convegno Internazionale delle Comunicazioni, 18th, Genoa, Italy, Oct. 12-16, 1970, Paper. 32 p.* 19 refs.

Service provided by various means of transportation is examined giving attention to cost factors and to the importance of door to door transport. If aircraft are to be introduced into residential areas there is a need to drastically reduce the noise level. Approaches for doing this are considered. Classes of aircraft discussed include the ABC helicopter, an advanced helicopter producing lift in the reversed flow region, a tilt wing/rotor aircraft and a stopped rotor aircraft. If much larger VTOL ports are permitted (diameter 3000 feet) then the fan lift aircraft is attractive for longer stages without intermediate stops. STOL aircraft are serious competitors for this market. The importance of the airfield as a growth point in area planning is investigated. G.R.

**A71-24283 Research and development of short and vertical takeoff - The Aladin 2 program (Recherches et développements sur le décollage court ou vertical - Le programme Aladin 2).** Jean Bertin, Jean Cayla, Louis Duthion, Paul Guienne, and Michel Perineau (Société Bertin et Cie., Paris, France). *L'Aéronautique et l'Astronautique*, no. 26, 1971, p. 3-23. In French.

Discussion of the Aladin 2 project, which consists in combining a wing fitted with suitable flaps and a number of propulsion units fitted with fish-tail nozzles to produce homogeneous mixtures within a rectangular ejector. It is thus possible to increase takeoff thrust, to obtain optimum wing flap blowing, and to greatly reduce noise. Various aircraft configurations have been drafted from this formula. It is considered that the quickest application could be by adapting an existing fuselage, such as that of the Nord 260, and that an Aladin 2-type aircraft should be able to supplement other transportation systems, such as motor vehicles, railways, and aerotrains. F.R.L.

**A71-24285 Toward the hypersonic aircraft (Vers l'aviation hypersonique).** Clément Dousset (Société Nationale Industrielle Aérospatiale, Paris, France). *L'Aéronautique et l'Astronautique*, no. 26, 1971, p. 37-46. In French.

Consideration of the hypersonic aircraft, which is expected to appear by the turn of the century, its justification being the increase in long distance traffic. The technical problems to be overcome are understood now, and a practical aircraft should be feasible in a few decades, especially if the space shuttle undergoes further development. The hypersonic aircraft will complete the range of transport aircraft (subsonic, supersonic, hypersonic) up to the region where true space travel begins. Some economic aspects are described. F.R.L.

**A71-24288 Automatic correction of sideslipping. II - Indirect-anticipation instrumentation (Correction automatique du dérapage. II - Instrumentation indirecte-anticipation).** René Jaeger (Breguet Aviation, Vélizy-Villacoublay, Yvelines; Centre de Documentation de l'Armement, Paris, France). *L'Aéronautique et l'Astronautique*, no. 26, 1971, p. 71-75. In French.

Combined use of a rudder position director and a transversal accelerometer to measure sideslipping in fighter aircraft. A high pass filter is used to optimize the automatic control loop of the sideslipping and to provide an anticipation (coupling of lateral control with direction) to reduce the initial sideslipping. The system should make it possible for fighter pilots to achieve high accuracy firing. F.R.L.

**A71-24300 Automated fueling for the jet-age airport.** George Feinman (Port of New York Authority, New York, N.Y.) and Bernard Sonenshein (General Electric Co., New York, N.Y.). *IEEE Transactions on Industry and General Applications*, vol. IGA-6, Nov.-Dec. 1970, p. 580-597.

The underground fueling system at John F. Kennedy International Airport provides for handling as many as 28 segregations of fuel. These fuels are transferred from a main or bulk storage area, laid out to accommodate 90 large tanks to a satellite or day tank area which is 2 miles closer to the terminals and consists of 40 small tanks. Identity of product by supplier and grade must be maintained in transferring fuel from the bulk to satellite tanks in five pipe-line transfer systems. Reassignment of tankage in both areas and pipe lines is made possible by flexible arrangement of mechanical equipment and piping. Control of the transfer requires automated valves, pumps, tank gauging, and other equipment in both tank farms. To provide supervision and control of this complex system, a data control system was designed, consisting of a GE 412 digital computer, solid-state supervisory system, and backup manual control. The real-time program incorporates many safety checks and alarms and the capability of matching the flexibility of the mechanical system without program changes. (Author)

**A71-24328 Condensation of argon in a supersonic stream.** T. Pierce, P. M. Sherman (Michigan, University, Ann Arbor, Mich.), and D. D. McBride (Sandia Corp., Albuquerque, N. Mex.). *Astronautica Acta*, vol. 16, Jan. 1971, p. 1-4. 5 refs. Contract No. AF 33(615)-67-C-1197.

Measurements were made of the location of onset of condensation in a supersonic nozzle. Argon was used as the condensing vapor in place of the more exotic vapors required in new space propulsion schemes (lithium vapor, for example). Measurements were made over a range of saturation pressures between 7 psia and 300 psia. The location of onset of condensation was determined by static pressure measurements. It was found that over the range of conditions considered, the vapor was supercooled to approximately 20 K beyond the saturation point. This result is shown to be consistent with computed results based on the classical liquid drop theory. (Author)

**A71-24336 A solution for equilibrium condensation on two component flow through a nozzle.** D. D. McBride (Sandia Corp., Albuquerque, N. Mex.) and P. M. Sherman (Michigan, University, Ann Arbor, Mich.). *Astronautica Acta*, vol. 16, Feb. 1971, p. 97-101. Contract No. AF 33(615)-67-C-1197.

Integrated solution which yields flow properties at a given nozzle area ratio without requiring a stepwise solution of the whole flow field downstream of the saturation point. The integrated equations are also combined into a single transcendental equation which may be solved graphically. Some results obtained for superheated zinc vapor in helium are presented. The solution is also used to obtain an approximation for the deviation of static

temperature and pressure from that for frozen flow (no condensation) for large area ratios for a range of stagnation chamber temperatures, pressures, and mass fractions of vapor. F.R.L.

**A71-24338 \*** Some studies of the turbulent wake problem. Joseph A. Schetz (Virginia Polytechnic Institute, Blacksburg, Va.). *Astronautica Acta*, vol. 16, Feb. 1971, p. 107-117. 28 refs. NASA-supported research; Contract No. N0w-62-0604-c.

Analytical and experimental study of the development of the mean-flow field of a turbulent wake behind a body in a fluid stream from low subsonic to hypersonic speeds. Existing experimental data are summarized, and new data for supersonic flow and a planar geometry are presented. The occurrence of strong normal pressure gradients in the planar geometry at both low and high speeds is discussed, as well as the analytical prediction of the downstream development of such flows, taking the conditions just beyond the near wake as initial conditions. It is shown that a unified treatment of the mean flow is possible in that the functional expression for the eddy viscosity can be used to provide good predictions of the data for the wake cases in the range  $M$  about equal to zero to  $M = 12$ . Particular attention is drawn to the important direct relationship between turbulent transport in the mean flow equations and the detailed characteristics of the turbulence in shear flows of the wake and jet type. F.R.L.

**A71-24353 #** A case of aperiodic motion of a wing near a solid surface (Pro odin vipadok aperiodychnogo rukhu krila poblizhu tverdoi poverkhni). G. S. Lipovoi (Akademiia Nauk Ukrain's'koi RSR, Institut Matematiki, Kiev, Ukrainian SSR). *Akademiia Nauk Ukrain's'koi RSR, Dopovidi, Seriya A - Fiziko-Tekhnichni i Matematichni Nauki*, vol. 32, Jan. 1971, p. 19-24. In Ukrainian.

Study of the aperiodic motion of a wing in the case where it jumps from one periodic state to another periodic state of different frequency. Laplace and Fourier transforms are used to reduce the boundary value problem for the partial differential equation to an ordinary differential equation and subsequently to a system of two integral equations. These are solved by the residue method. T.M.

**A71-24362 #** The effect by which a flapping wing utilizes the kinetic energy of the wake (Pro efekt vikoristannia mashuchim krilom kinetichnoi energii slidu). Iu. M. Savchenko (Akademiia Nauk Ukrain's'koi RSR, Institut Gidromekhaniki, Kiev, Ukrainian SSR). *Akademiia Nauk Ukrain's'koi RSR, Dopovidi, Seriya A - Fiziko-Tekhnichni i Matematichni Nauki*, vol. 32, Jan. 1971, p. 78-80. In Ukrainian.

Measurements of instantaneous hydrodynamic forces acting on a flapping wing show that the wing can utilize the kinetic energy in the wake to create thrust at low translational speeds or when operating in a hover mode. The mean thrust obtained can be three to four times larger than that calculated from the maximum steady-state coefficients of aerodynamic forces applied to the wing. T.M.

**A71-24368 #** Effect of the incident flux parameters and the wall temperature on the flow characteristics in the pre-separation zone of a laminar boundary layer (Vliianie parametrov nabegaiushchego potoka i temperatury stenki na kharakteristiki techeniia v predotrynoi zone laminarnogo pogranichnogo sloia). V. V. Vasiukov. *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza*, Jan.-Feb. 1971, p. 76-82. 5 refs. In Russian.

Results of calculations concerning the effect of various factors on the flow characteristics in the pre-separation zone of a laminar boundary layer and the location of the separation point. A study is made of the effect of the wall temperature on the flow in the

pre-separation zone and on the location of the separation point at various incident flow Mach numbers (particular attention is paid to cases of strong cooling of the wall). The effect of the Prandtl number and the temperature dependence of the viscosity on the location of the separation point of a laminar boundary layer is considered for various wall temperatures and Mach numbers. Data are obtained concerning the effect of wall temperature, Mach number, temperature dependence of viscosity, and Prandtl number on the distribution of thermal fluxes and friction in the pre-separation zone of a laminar boundary layer. It is shown how various methods of assigning the pressure distribution along the body surface affect the location of the separation point and the distribution of thermal fluxes and friction. A.B.K.

**A71-24370 #** Axisymmetric minimal-drag bodies in a viscous hypersonic flow (Osesimmetrichnye tela minimal'nogo soprotivleniia v viazkom giperzvukovom). V. D. Parminov. *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza*, Jan.-Feb. 1971, p. 90-96. 12 refs. In Russian.

Formulation and numerical solution of the problem of axisymmetric minimal-drag bodies with given length, relative thickness, volume, or total heat flux in a hypersonic viscous gas flow. Assuming that the pressure on the body surface is given by a modified Newton's law, the friction coefficient is determined by the method of local variations. A.B.K.

**A71-24371 #** Aerodynamic characteristics of star-shaped bodies at supersonic velocities (Aerodinamicheskie kharakteristiki zvezdoobraznykh tel pri sverkhzvukovykh skorostiakh). A. L. Gonor, M. N. Kazakov, A. I. Shvets, and V. I. Shein (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR). *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza*, Jan.-Feb. 1971, p. 97-102. 5 refs. In Russian.

Results of an experimental determination of the overall aerodynamic characteristics and the flow pattern in the wake behind a star-shaped body in a wide range of Mach numbers from 2.5 to 8.0 and for angles of attack ranging from 0 to plus or minus 8 deg. The aerodynamic characteristics of two models of star-shaped bodies with four and six lobes, respectively, are obtained, and a comparison is made with the characteristics of an equivalent cone and the characteristics of a 'star' with ten lobes. For comparison with experimental data a calculation is made of the drag and the location of the shock waves. A.B.K.

**A71-24372 #** A vortex layer on a circular cone (O vikhrevom sloe na krugovom konuse). B. M. Bulakh. *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza*, Jan.-Feb. 1971, p. 103-108. In Russian.

Consideration of the problem of a vortex layer arising near the surface of a circular cone in an asymmetrical steady flow of a homogeneous supersonic inviscid gas. In contrast to other works, including a previous work by the author (1962), where the angle of attack was assumed to be small, in the present work the main terms of the gasdynamic parameters near the cone surface are determined for an arbitrary angle of attack. A.B.K.

**A71-24373 #** Linear theory of supersonic flows of a mixture of a gas and particles (K lineinoi teorii sverkhzvukovykh techenii smesi gaza i chastits). R. A. Tkachenko. *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza*, Jan.-Feb. 1971, p. 109-119. 9 refs. In Russian.

Derivation of a partial differential equation for the perturbation potential which describes weakly perturbed two-phase supersonic plane axisymmetric flows. The desired equation is derived within the framework of a linear theory proposed by Kraiko and Tkachenko

(1968). A general solution to this equation is obtained with the aid of a Laplace transformation. The transition to the plane of the originals is achieved in the entire flow region near thin plane axisymmetric bodies, either rarefaction waves or weak shock waves being obtained near points of deflection of the contour. A.B.K.

**A71-24376 # Numerical solution by the build-up method of the problem of the mixed axisymmetric gas flow in certain curvilinear regions (Chislennoe reshenie zadachi o smeshannom osesimmetricheskom techenii gaza v nekotorykh krivoliniynykh oblastiakh metodom ustanovleniia).** I. M. Vasenin and A. D. Rychkov. *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza*, Jan.-Feb. 1971, p. 155-159. 9 refs. In Russian.

The build-up method is applied to the calculation of a gas flow with uniform and nonuniform enthalpy in a curvilinear region with a continuous upper boundary, and also to the calculation of a nonuniform-enthalpy flow in a region with a discontinuity of the cross-sectional area. In this method, a steady gas flow is treated as a time-limited nonstationary flow. The curvilinear portion of the region is rectified by introducing new independent variables, and the condition under which such a transformation does not influence the form of the conservation laws is derived. It is shown that flow in such regions do not lend themselves to description by one-dimensional theory. V.P.

**A71-24378 # Experimental investigation of the effect of intensive injection of various gases on a turbulent boundary layer (Eksperimental'noe issledovanie vliianiia intensivnogo vduva razlichnykh gazov na turbulentnyi pogranichnyi sloi).** V. M. Eroshenko, A. L. Ermakov, A. A. Klimov, V. P. Motulevich, and Iu. N. Terent'ev. *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza*, Jan.-Feb. 1971, p. 162-167. 7 refs. In Russian.

A channel with lateral interferometric-frequency glass walls and a porous area in the lower wall was used in a study of the turbulent boundary layer of a subsonic airflow during the injection of air and carbon dioxide through the porous area into the channel. An interferometer was used for recording the structural features of the boundary layer during injection. The flow concentration and velocity profiles in the boundary layer vs injection rates are determined. V.Z.

**A71-24379 # Profiling of nozzles using gases with condensate particles (O profilirovani sopl, rabotaiushchikh na gaze s chastitsami kondensata).** G. V. Dritov and A. P. Tishin. *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza*, Jan.-Feb. 1971, p. 170-175. 16 refs. In Russian.

Optimal contour geometries are determined by a direct variational procedure for supersonic gas turbine nozzles when the working gas carries condensed particles. Available data concerning the motion of real polydispersed condensate systems with roughly 30% Al<sub>2</sub>O<sub>3</sub> particles are used as the basis for calculating the dynamic characteristics of a nonequilibrium gas-solid flow in nozzles of various geometries. Diagrams are given to show families of trajectories of individual solid particles in supersonic nozzles of various designs. Tentative considerations are given for designing supersonic nozzles using gases with suspended solid particles. V.Z.

**A71-24380 # Calculation of nozzle two-phase losses in the case of coagulation and atomization of condensate droplets (Raschet dvukhfaznykh poter' v soplakh pri nalichii koagulyatsii i drobeniia kapel' kondensata).** G. L. Babukha, L. E. Sternin, and A. A. Shraiber. *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza*, Jan.-Feb. 1971, p. 175-177. 5 refs. In Russian.

The interaction between a large stationary (target) droplet and a stream of small incident droplets is studied experimentally. The peculiarities of the behavior of colliding droplets revealed by

high-speed photography lead to a simplified model of the process, where the diameter of the atomized droplets is taken as that of the small droplets and their velocity as that of the large droplets. This model is used to derive a method of calculating nonequilibrium flows of a two-phase mixture (consisting of a gas and condensate droplets) with allowance for both the coagulation and atomization of colliding droplets. V.P.

**A71-24406 Effects of blowing or suction on the laminar boundary layer flow over a rotating cone.** Shoichiro Fukusako, Masaru Kiya, and Mikio Arie (Hokkaido University, Sapporo, Japan). *Applied Scientific Research*, vol. 23, Dec. 1970, p. 269-280. 6 refs.

Description of the effects of suction or blowing at the surface of a rotating cone in a quiet fluid on skin friction and heat transfer. The equations governing the fluid motion and thermal energy transfer are transformed by the boundary layer approximations, and the resulting equations are solved under the condition that the suction or blowing velocity varies as  $x$  to the  $n$ th ( $x$  being the distance measured from the apex of the cone, and  $n$  an arbitrary constant). The solutions are obtained as a perturbation from the basic laminar flow of an incompressible viscous fluid over the impermeable rotating cone. Detailed numerical calculations are performed for the case of an isothermal rotating cone with uniform blowing or suction (i.e.,  $n = 0$ ), the Prandtl number being 0.72. Results are given for the shear stress, heat transfer, and velocity and temperature fields. It is shown from the analysis that suction sharply increases the circumferential shear stress and the heat transfer at the surface. (Author)

**A71-24420 Conclusive tests of a model of the Marchetti Rotormobile (Essais conclusifs d'une maquette du 'Rotormobile' de Marchetti).** Jacques Morisset. *Air et Cosmos*, vol. 8, Feb. 13, 1971, p. 24-26. In French.

Discussion of the telecontrolled Rotormobile lifting vehicle, or flying crane, the basic element of which is a jet-powered lifting rotor. There is no fuselage or antitorque rotor, and no landing gear other than an air cushion. Its purpose is to lift heavy loads over short distances. Because of its simplicity it should be cheaper to build than the conventional helicopter with its fragile blades and complex rotor head, and should be less expensive to maintain. Tests made in the Tarbes wind tunnel showed a useful load/weight empty ratio double that of the best helicopters. It makes possible the transport of heavy loads without the size limitations imposed by road or rail transportation. F.R.L.

**A71-24453 Determination of the plane irrotational motion of an ideal incompressible fluid driven by the displacement and deformation of a constant-area airfoil (Détermination du mouvement plan irrotationnel, d'un fluide parfait incompressible animé par le déplacement et la déformation d'un profil d'aire constante).** Roland Laporte. *Académie des Sciences (Paris), Comptes Rendus, Série A - Sciences Mathématiques*, vol. 272, no. 9, Mar. 1, 1971, p. 621-623. In French.

Determination of the motion of an ideal incompressible fluid due to the displacement of a deformable constant-area airfoil. A study is made of the velocity potential of the fluid motion, and those motions and deformations of pointed airfoils are characterized for which the Joukowski condition does not involve any vortex leakage. The motions of a deformable airfoil which are compatible with a holomorphic fluid velocity are ascertained. A.B.K.

**A71-24454 Obtaining flows with a velocity which is a harmonic function of time (Sur l'obtention d'écoulements dont la vitesse est une fonction harmonique du temps).** Hubert Mainardi, Max Plan, and Jean-Michel Thomas (Orléans, Université, Orléans, France). *Académie des Sciences (Paris), Comptes Rendus, Série A -*

*Sciences Mathématiques*, vol. 272, no. 9, Mar. 1, 1971, p. 624-626. In French.

Description of an experiment in which a flow with a velocity obeying a harmonic law was obtained in a wind tunnel. The flow rate was controlled by a sonic striction located downstream from the test jet. The cross section of this striction was made to vary periodically in time by means of a pulsator consisting of a central valve shutter displaced by a periodic motion along the axis of a convergent-divergent nozzle. It is shown that the harmonic distortion of the flow remains low even for a modulation rate of 50 per cent. A.B.K.

**A71-24483 Normal shock wave reflection on deformable solid walls.** Rodolfo Monti (Napoli, Università, Naples, Italy). *Meccanica*, vol. 5, Dec. 1970, p. 285-296. Research supported by the Consiglio Nazionale delle Ricerche.

Theoretical and experimental investigation of the interaction between normal shock waves and deformable solid materials, with emphasis on the characteristics of the reflected shock wave. A theoretical analysis gives a solution for the shock wave intensity reflected into the gas and for the transmitted shock wave propagating into the elastic solid material for both cases of linear and nonlinear solids. For the first type of materials a closed form solution is found. For nonlinear materials the problem is solved through a numerical analysis. Experiments were made on two types of expanded foams (closed-cell and open-cell foams). The theoretical analysis is in very good agreement with the experiments, especially taking into account the correction for the gap between shock tube and model walls. M.M.

**A71-24517 \* # Ion acoustic wave detection using a continuous channel electron multiplier.** Wilhelm K. Rehmann and Nobie H. Stone (NASA, Marshall Space Flight Center, Space Sciences Laboratory, Huntsville, Ala.). *Review of Scientific Instruments*, vol. 42, Apr. 1971, p. 529, 530. 5 refs.

Description of measurements made in a plasma wind tunnel of the propagation and structure of ion acoustic waves using both the metal electrode technique and the continuous channel electron multiplier. The results obtained with both methods for two values of plasma density are shown. At higher densities, the signals attained from the Channeltron and the metal grid electrode are approximately equal. However, at the lower value of plasma density, the metal grid signal vanishes while the Channeltron signal remains almost unchanged. The relatively low maximum output current for which the Channeltron response is linear requires that some care be exercised to avoid the occurrence of saturation effects when acoustic wave signals are received at higher plasma densities. M.M.

**A71-24520 Ideal fluid flow in an enclosure of toroidal geometry.** M. Jakubowski (IBM Corp., Endicott, N.Y.), A. A. Kovitz, and S. Raynor (Northwestern University, Evanston, Ill.). *International Journal of Non-Linear Mechanics*, vol. 6, Feb. 1971, p. 101-115.

Ideal fluid flow in a space of toroidal geometry is studied with the aim of obtaining steady state solutions for flow patterns useful in the design of turbomachinery. Attention is focused on rotational flow. The governing equations are referred to a polar toroidal coordinate system. The problem is reduced to the solution of a homogeneous, nonlinear, third order partial differential equation for a stream function with an associated set of boundary conditions. Solutions of the stream function equation are obtained by a power series representation valid in some neighborhood of the outer boundary (the shell). This results in a set of linear first order ordinary differential equations which can be solved consecutively, and exhibits explicitly the connection between the fluid velocity and the body forces. Some numerical examples of particular flows are presented. M.V.E.

**A71-24565 # Cylindrical shell of finite length in a fluid flow (Tsilindricheskaia obolochka konechnoi dliny v potoke zhidkosti).** V. N. Buivol (Akademiia Nauk Ukrainskoi SSR, Institut Hidromekhaniki, Kiev, Ukrainian SSR). *Prikladnaia Mekhanika*, vol. 7, Jan. 1971, p. 43-48. 8 refs. In Russian.

An approximate method of determining critical speeds for potential flows of an inviscid compressible fluid past thin-walled elastic cylindrical shells is proposed. The method, based on the use of a long-wave approximation, makes it possible to obtain the critical velocity in explicit form. The explicit formula can be used to analyze the critical velocity as a function of the shell parameters. V.P.

**A71-24588 A radiating gas jet. I - Optically thick plane jet.** Hsiao C. Kao (Northrop Corp., Aircraft Div., Hawthorne, Calif.). *Quarterly Journal of Mechanics and Applied Mathematics*, vol. 24, Feb. 1971, p. 1-21. 9 refs.

The inviscid flowfield of a high-temperature jet exhausting from a two-dimensional nozzle into a low-temperature quiescent medium is analyzed. The gas is assumed to be optically grey and thick. This problem is shown, under the appropriate conditions, to be a singular perturbation one due to the formation of radiation boundary layers and is solved accordingly. To illustrate the procedure, the analysis is followed by a numerical example. (Author)

**A71-24589 Aerofoil theory for a stratified fluid.** D. G. Hurley (Western Australia, University, Nedlands, Australia). *Quarterly Journal of Mechanics and Applied Mathematics*, vol. 24, Feb. 1971, p. 37-42. 8 refs. NSF Grant No. GA-641X.

Previous investigations of the flow of a stratified fluid past a symmetrical airfoil at zero incidence are extended to include the effects of camber and incidence. The effect of stratification on the integral equation of airfoil theory is determined and the modified equation is solved approximately for the loading in the case when the inverse Froude number is small. It is shown that when this is the case the intensity of the internal waves due to lift should be much larger than that due to thickness. M.V.E.

**A71-24592 The lip shock during expansion of a supersonic boundary layer (Der Ablösestoß bei der Expansion einer Überschall-Grenzschicht).** Wolfgang Merzkirch (Ruhr-Universität, Bochum, West Germany). *Zeitschrift für Flugwissenschaften*, vol. 19, Jan. 1971, p. 1-12. 15 refs. In German.

In the case of the separation of a supersonic boundary layer, for instance at the base of a flying body, an oblique shock results following the expansion fan, and distorts the boundary layer profile. On the basis of the reflection and refraction of Mach waves in an anisentropic, isobar supersonic flow, the strength of this shock is determined for the two-dimensional case. The numerical results are discussed using the numerous experimental findings by Hama. (Author)

**A71-24593 Studies of the effects of an inclined engine jet on the aerodynamic properties of tail control surfaces (Untersuchungen über den Einfluss eines geneigten Triebwerkstrahls auf die aerodynamischen Eigenschaften eines Leitwerks).** Manfred Seidel (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Institut für Aerodynamik, Braunschweig, West Germany). *Zeitschrift für Flugwissenschaften*, vol. 19, Jan. 1971, p. 13-19. 52 refs. In German. Research supported by the Bundesministerium der Verteidigung.

In a basic experimental study the change in lift of an 'isolated' tailplane induced by a cold circular jet is determined. With regard to the longitudinal stability of a VTOL aircraft in the transition speed range, a dominant parameter is the angle of the jet nozzle relative to the mainstream direction. As further parameters the jet-speed to

mainstream-speed ratio, the diameter of the nozzle and its position relative to the tailplane, the incidence, the chord and the thickness of the tailplane are investigated. Systematic force and pressure measurements have been carried out on several tailplane models (NACA 0010 section and flat plate with a rounded nose) of rectangular planforms and with sideplates. The results provide a survey on the magnitude of jet-induced tailplane contributions to changes in stability and may allow to estimate roughly engine-efflux effects in an early design stage of an aircraft. Some fluid-mechanical aspects of the spreading and interference of inclined jets are discussed. The testing installation and performance are briefly described. (Author)

**A71-24616 # A study of free jet impingement.** I. Coleman Dup. Donaldson and Richard S. Snedeker (Aeronautical Research Associates of Princeton, Inc., Princeton, N.J.). *Journal of Fluid Mechanics*, vol. 45, Jan. 30, 1971, p. 281-319. 17 refs. Contract No. Nonr-3903(00) (X).

The mean properties of the flow field are established. Velocity profiles are given for three types of jet flow issuing from a circular convergent nozzle. Measured distributions of surface pressure are given which result when the jets impinge both normally and obliquely at various distances on several surface shapes. The pressure distributions are used to compute the radial velocity gradient at the impingement stagnation point. It is found that for normal impingement this gradient correlates with the free jet centerline velocity and half-radius at the same axial location. A fall-off in the correlated value is noted as the impingement is made oblique. Measurements of the azimuthal distribution of momentum flux in the resulting wall jet are given. M.M.

**A71-24622 # A note on turbulent shear-layer reattachment downstream of a backward-facing step in confined supersonic two-dimensional flow.** T. Mukerjee (Imperial College of Science and Technology, London, England), A. Farshi (National Petrochemical Co., Shiraz, Iran), and B. W. Martin (Wales, University, Cardiff, Wales). *Journal of Fluid Mechanics*, vol. 46, Mar. 29, 1971, p. 293-297. 15 refs.

The reattachment of a supersonic jet with a turbulent separating boundary layer abruptly expanding into a two-dimensional parallel diffuser has been experimentally investigated using a surface-flow technique. The reattachment criterion proposed by Mukerjee and Martin (1969) for axisymmetric confined and unconfined flows is found to correlate equally well similar two-dimensional flow measurements in terms of the free-stream Mach number after separation. (Author)

**A71-24643 # Local analysis of nonlinear forced vibrations of a plate of finite length in two-dimensional supersonic flow.** Z. Dzygadlo. *Proceedings of Vibration Problems*, vol. 11, no. 4, 1970, p. 353-368. 12 refs.

The vibrations of a plate loaded by harmonically varying pressure are studied, with allowance for the nonlinearity of the elastic forces and for the nonlinear action of the flow on the vibrating plate. A solution is obtained in the form of a series in eigenfunctions of the plate variations in vacuo. An asymptotic single-frequency method of analysis is applied to the vibrations. The local resonance characteristics are studied for near-critical parameters of the natural vibrations of the system. Numerical results obtained reveal the strong influence of the system nonlinearity on the resonance characteristics at subcritical Mach numbers. The behavior of the resonance characteristics at supercritical Mach numbers is also examined. Nonlinear forces at supercritical Mach numbers are shown to lead to new phenomena resulting from the coupling between forced and self-excited vibrations at the limit cycle. V.P.

**A71-24670 # Technical operation and reliability of aircraft radio equipment** (Tekhnicheskaya ekspluatatsia i nadezhnost' avia-

tsionnogo radiooborudovaniia). V. S. Novikov. Moscow, Izdatel'stvo Transport, 1970. 233 p. 17 refs. In Russian.

The fundamentals of the theory of reliability and operation of radio equipment are outlined. Information concerning the conditions of operation of ground and onboard radio equipment is presented. Quantitative reliability parameters are considered, as well as methods of calculating and testing the reliability of radio equipment and the use of redundancy and rational methods of operation to improve the reliability. Engineering devices are described, including automatic systems for controlling the technical state of radio equipment. A.B.K.

**A71-24726 # Optimal stabilization of a control system with continuously acting small mean disturbances** (Ob optimal'noi stabilizatsii upravliaemoi sistemy pri postoianno deistvuiushchikh vozmushcheniakh malykh v srednem). E. I. Dergacheva. *Avtomatika i Telemekhanika*, Jan. 1971, p. 17-22. 8 refs. In Russian.

The equations of motion of a controlled plant  $dx/dt = Ax + Bu + f(x, u, t)$  are analyzed, where  $x$  is an  $n$ -dimensional vector of the phase coordinates,  $u$  is an  $m$ -dimensional control vector,  $f$  is an  $l$ -dimensional vector of a continuously acting perturbing force,  $A, B$ , are  $n \times n$  and  $n \times m$  constant matrices, and  $t$  is time. The boundary conditions correspond to constantly acting forces that are small in the mean. The results of the analysis are applied to the stabilization of the horizontal flight of an aircraft in the presence of vertical gusts. V.P.

**A71-24749 # Influence of lift and cruise engine design on the transition characteristics and ground acoustic field of VTOL transport aircraft** (Einfluss der Hub- und Reisetriebwerkauslegung auf die Transition und das Bodenschallfeld vertikalstartender Transportflugzeuge). H. Pakendorf and G. Böttger (Vereinigte Flugtechnische Werke-Fokker GmbH, Bremen, West Germany). *Deutsche Gesellschaft für Luft- und Raumfahrt, Symposium über VTOL-Antriebe, Munich, West Germany, Oct. 22, 23, 1970, Paper DGLR 70-040*. 47 p. 13 refs. In German.

A transition technique for maximum horizontal acceleration is used to evaluate the influence of engine design and thrust-vector control on the transition characteristics. It is shown that the vertical balance of forces in transition, and hence the transition characteristics, are influenced directly by the input-output impulse ratio and by the thrust-vector control characteristics of the lift and cruising engines, and indirectly by optimal adaptation of the cruising engines to the cruising flight requirements and by the number of lift and cruising engines installed. A parametric analysis of mixed and direct lift configurations shows that thrust-vector control over an angle of at least 30 deg for the lift engines is essential for ensuring safe transition. V.P.

**A71-24750 Some design considerations for a low noise, direct lift, VTOL engine.** P. A. Taylor (Rolls-Royce, Ltd., Derby, England). *Deutsche Gesellschaft für Luft- und Raumfahrt, Symposium über VTOL-Antriebe, Munich, West Germany, Oct. 22, 23, 1970, Paper*. 15 p.

Design optimization procedures used to minimize noise levels in direct-lift VTOL engines. Noise mechanisms and characteristics are identified for such source parameters as rotor tip speeds, fan pressure ratio, rotor-stator axial gap, inlet axial velocity, inlet hub-tip ratio, inter rotor-stator axial diffusion, rotor and stator chords, and acoustic liner thickness. Methods in which these parameters can be varied to minimize generated noise are outlined, and the use of silencers for further improvement is demonstrated. The noise level of a typical lift fan engine designed in the proposed manner is then related to the various operating noise limits proposed for civil VTOL aircraft. T.M.

**A71-24751**      The present 'state of the art' of VTOL engines. A. Stewart (Rolls-Royce, Ltd., Derby, England). *Deutsche Gesellschaft für Luft- und Raumfahrt, Symposium über VTOL-Antriebe, Munich, West Germany, Oct. 22, 23, 1970, Paper. 11 p.*

Heat engine and propulsion system design and performance of VTOL aircraft constructed by Rolls-Royce are reviewed. The Pegasus jet lift engine is noted as an example of compromise between takeoff and cruise functions yielding a compression ratio of 11.7. Specific thrust and bypass ratio vs exhaust and fan velocities are plotted. Specifications are listed for the principal VTOL engines available, being developed, or planned by Rolls-Royce. V.Z.

**A71-24752 #**      Safety requirements and their effect on VTOL power plants (Sicherheitsforderungen und ihre Auswirkungen bei VTOL-Triebwerksanlagen). Heinz G. Klug (Hamburger Flugzeugbau GmbH, Hamburg, West Germany). *Deutsche Gesellschaft für Luft- und Raumfahrt, Symposium über VTOL-Antriebe, Munich, West Germany, Oct. 22, 23, 1970, Paper. 15 p. 8 refs. In German.*

Analysis of the breakdown rate of VTOL lift engines, including recommendations regarding ways of preventing catastrophic damage to these engines. The probabilities of the occurrence of single and double breakdowns are determined, and the consequences of such breakdowns for VTOL design are assessed. Dangers arising from disintegrating engines are discussed. A.B.K.

**A71-24753 #**      Effect of propulsion system and controller design on the thrust change at the ejection of air for aircraft stabilization in hovering flight (Einfluss der Triebwerks- und Reglerauslegung auf die Schubänderung bei Luftabbläsung zur Flugzeugstabilisierung im Schwebeflug). K. Bauerfeind (Motoren- und Turbinen-Union München GmbH, Munich, West Germany). *Deutsche Gesellschaft für Luft- und Raumfahrt, Symposium über VTOL-Antriebe, Munich, West Germany, Oct. 22, 23, 1970, Paper. 18 p. In German.*

The effect of variations in a number of propulsion system design parameters for vertical takeoff aircraft was investigated including turbine inlet temperature and pressure ratios. The approaches for fuel control considered are based on a constant supply of fuel, on constant speed of the rotor of the compressor, and on a constant turbine inlet temperature, respectively, for various adjustments of the control unit. The smallest decrease in total thrust was obtained for a constant rotor speed and total pressure ratio of 20 or higher. The turbine inlet temperature was found to have little effect. G.R.

**A71-24755 #**      Basic principles for regulating turboprop and turboshaft engines (Podstawowe zasady sterowania turbinowych silników śmigłowych i śmigłowcowych). Leszek Kruś and Stefan Szczeciński. *Technika Lotnicza i Astronautyczna*, vol. 26, Jan. 1971, p. 7-9, 14. 12 refs. In Polish.

Interrelationships among the operational characteristics of turboprop engines are examined to illustrate the control requirements. Curves show the dependence of torque and power on engine speed for both single-shaft and twin-shaft (separate drive turbine) engines. Block diagrams are given; for the control sequences and control points in different engine layouts. T.M.

**A71-24756 #**      Strengthening of airport surfaces (Wzmocnianie nawierzchni lotniskowych). Franciszek Kaźmierczyk. *Technika Lotnicza i Astronautyczna*, vol. 26, Jan. 1971, p. 18-21, 39. In Polish.

Description of methods for strengthening existing runway surfaces by overlaying additional rigid or flexible layers or by completely replacing highly used sections by stronger segments. Typical cross sections of new surface layers are illustrated, and problems of joining, preparation, and reinforcement are examined. T.M.

**A71-24761 #**      Transonic shear flow past a symmetric airfoil. Masanobu Namba (Kyushu University, Fukuoka, Japan). *Kyushu University, Faculty of Engineering, Memoirs*, vol. 30, Nov. 1970, p. 51-67. 15 refs.

A linearized small-disturbance theory is developed that can be applied to a symmetric airfoil in a nonuniform transonic shear flow whose Mach number varies across the span of the airfoil. The effect of compressibility in nonuniform flows is investigated. A noticeable difference is found between the compressibility effects of transonic shear flows and those of uniform flows. This difference explains the failure of strip theory approximations when applied to transonic shear flows. Some numerical examples are presented and discussed. M.V.E.

**A71-24762**      Application outlook for titanium P/M parts. Robert H. Gassner, S. M. Weiman (Douglas Aircraft Co., Long Beach, Calif.), and W. R. Raymont. *Metal Progress*, vol. 99, Apr. 1971, p. 66-68.

Prospects for the use of powder metallurgy parts in aircraft are illustrated by the example of a flareless-sleeve coupling nut made of a pressed and sintered Ti-6Al-4V alloy. The part is molded in conventional powder metallurgy tooling without internal or die-wall lubricants and is then sintered in a high vacuum to eliminate atmospheric contamination. The resultant product has a density of about 96%, a tensile strength of 137,000 psi, yield strength of 123,000 psi, and 7% elongation in 1 in. Z.W.

**A71-24770**      Advanced filamentary composites for primary aircraft structures. S. Dastin (Grumman Aircraft Engineering Corp., Bethpage, N.Y.). In: *Polyblends and composites; Polytechnic Institute of Brooklyn, Seminar, Polytechnic Institute of Brooklyn, Brooklyn, N.Y., June 6, 7, 1969, Proceedings.* New York, Interscience Publishers (*Applied Polymer Symposia*, no. 15), 1970, p. 81-92.

Advanced filamentary composites considered for primary aerospace structural applications, particularly boron-epoxy, are discussed and several typical examples are given. Mechanical property data, preliminary design allowables, and resultant weight savings are presented along with the generalized manufacturing and quality control techniques presently employed. (Author)

**A71-24774**      Air traffic control system - Digital simulation facility. John R. Vander Veer and Louis J. Bona (FAA, National Aviation Facilities Experimental Center, Atlantic City, N.J.). *Simulation*, vol. 16, Jan. 1971, p. 5-17.

Description of the digital simulation facility of the new air traffic control system near Atlantic City, N.J., now serving as a tool in research, development and testing of futuristic air traffic control concepts and systems. The facility allows for improved real-time systems simulation and is currently being used to support two important projects aimed at improving control and safety of air traffic: (1) evaluation of the interaction between a proposed airborne collision avoidance system and the air traffic control system, and (2) validation of the various automation levels in the air-terminal automation development program. The description covers the operation of the system; the hardware it consists of; and the software required to control the equipment, to simulate aircraft flights, and to collect and reduce data. The advantages of the new facility are discussed. M.V.E.

**A71-24811 \* #**      Measurements of the refraction and diffraction of a short N wave by a gas-filled soap bubble. Bruce A. Davy and David T. Blackstock (Rochester, University, Rochester, N.Y.). *Acoustical Society of America, Journal*, vol. 49, Mar. 1971, pt. 2, p.

732-737. 12 refs. NASA-USAF-supported research.

Description of a laboratory model experiment carried out to test Pierce's (1968) suggestion that peaking and rounding in the pressure signatures of sonic booms are the result of refraction and diffraction caused by atmospheric inhomogeneities. N waves about 1-cm long were produced by an electric spark, refracted and diffracted by a gas-filled soap bubble, and received by a very wide-range condenser microphone. The bubble acted as a converging acoustic lens when it was filled with argon and as a diverging lens when filled with helium. It was found that the converging lens caused peaking of the N wave, while the diverging lens caused rounding. These results qualitatively support Pierce's theoretical model. M.M.

**A71-24816**      **Radiation of sound by airfoils that accelerate near the speed of sound.** Richard H. Lyon (Bolt Beranek and Newman, Inc.; MIT, Cambridge, Mass.). *Acoustical Society of America, Journal*, vol. 49, Mar. 1971, pt. 2, p. 894-905. 6 refs.

This work shows theoretically that airfoils accelerating at a speed near to, but less than, the speed of sound can be powerful emitters of sound. The sound generation is due to both lift and thickness effects. The airfoil is replaced by volume velocity and body force distributions, and the solutions are obtained by standard methods. A rotating blade is replaced by a lineal progression of accelerating 'torpedoes' representing the rotor tips. The sound of lift and thickness effects is radiated strongly forward. Sound power calculations made for thickness radiation alone for a series of airfoil shapes show some reduction of radiated sound with tip shape, and a promising correlation with experimental results. (Author)

**A71-24817 \* #**      **Statistical theory of atmospheric turbulence effects on sonic-boom rise times.** Allan D. Pierce (MIT, Cambridge, Mass.). *Acoustical Society of America, Journal*, vol. 49, Mar. 1971, pt. 2, p. 906-924. 46 refs. NASA-supported research.

The measured sonic-boom rise times at ground level are typically of the order of 1-10 msec, which is two to three orders of magnitude larger than what would be predicted on the basis of a planar shock propagating in a homogeneous atmosphere. A tentative explanation of how such anomalous rise times are caused by atmospheric turbulence is given in terms of the Keller-Friedlander geometrical acoustics theory of weak shock propagation in an inhomogeneous medium. It is suggested that the shock front initially develops ripples that subsequently are transformed into folds in the front when the shock passes vertices of caustics. This wavefront-folding mechanism may produce sonic-boom signatures that have a fine structure consisting of many small pressure jumps (microshocks), each jump corresponding to a segment of the folded wavefront. To assess the mechanism's effectiveness quantitatively, a stochastic model of an initially sharp shock propagating through the earth's turbulent boundary layer is derived. M.M.

**A71-24819**      **Mitsubishi 60 cm trisonic wind tunnel.** H. S. Kuroiwa, M. Ikai, T. Kurata, A. Kubozono, and T. Sibata. *Mitsubishi Heavy Industries Technical Review*, vol. 7, no. 6, 1970, p. 1-9. In Japanese, with abstract in English.

Review of calibration tests in the trisonic wind tunnel. The results include the effects of the second throat, reentry slots and reentry flaps in the transonic speed range, Mach number distribution and flow inclination in a test section, static pressure distribution on the surface of a cone cylinder, and aerodynamic characteristics of AGARD-B and AGARD-C calibration models. F.R.L.

**A71-24821**      **Fatigue strength of aluminum materials at higher temperatures (Schwingfestigkeit von Aluminiumwerkstoffen bei höheren Temperaturen).** G. Jacoby and H. Laudert (Carl Schenck Maschinenfabrik GmbH, Darmstadt, West Germany). *Aluminium*,

vol. 46, Dec. 1970, p. 799-804. 9 refs. In German.

Aluminum alloys which might possibly be suitable for applications as structural components with environmental temperatures not exceeding for any long time period 120 to 170 C are investigated. The alloys include materials alloyed with Cu and Ni, a Li containing material, and a material containing Cu, Mn, Zr, and V in addition to aluminum. Tensile tests conducted at room temperature and at 100, 150, 200, and 250 C are discussed, and one-step fatigue tests are reported. Other fatigue tests described were conducted as programmed investigations at various temperatures. The aluminum alloys studied are compared with a material containing Co, Cr, W, and Ni, which has excellent high-temperature characteristics, taking into account weight factors. G.R.

**A71-24824**      **Air cargo transport - Status and development tendencies (Luftfrachttransport - Stand und Entwicklungstendenzen).** W. Meyer (Aluminium-Zentrale, Düsseldorf, West Germany). *Aluminium*, vol. 46, Dec. 1970, p. 820-824. 12 refs. In German.

The increase in air cargo volume during the time from 1960 to 1969 is examined considering the situation in various airports and in the countries of the International Civil Aviation Organization. The aircraft which are mainly used for transporting air cargo are discussed, and a table is presented showing some technical data regarding the aircraft. Another table contains numbers concerning the orders which have been placed for various aircraft models. Technological aspects of air cargo storage are described giving attention to container design and container handling. G.R.

**A71-24834**      **Propagation of fan noise in cylindrical ducts.** Ulrich Bolleter (Purdue University, Lafayette, Ind.) and Robert C. Chanaud (Colorado, University, Boulder, Colo.). *Acoustical Society of America, Journal*, vol. 49, Mar. 1971, pt. 1, p. 627-638. 24 refs. Research supported by the Air Conditioning and Refrigeration

The propagation of random sound in a cylindrical duct has been treated theoretically. The conditions under which the simple wave equation applies to the transmission of sound generated by industrial air-moving devices is made explicit. The acoustic forcing function and termination conditions are discussed extensively as well as the structure of the sound field in the duct. Equations for the power spectral density and pressure cross-spectral density are derived in order to define the problems associated with deducing sound power, given sound pressure at two points. The results suggest that an anechoic termination is almost mandatory and that the modal spectra must be known, if accurate measurements are to be made. A number of simplifications to the theory were tested experimentally and found to apply. Modal spectra were measured and were used to compute sound power and predict pressure measurements. The predicted and observed were found to be within 1 dB, suggesting that a practical means for measuring ducted-fan sound power can be found. (Author)

**A71-24850**      **V/STOL and variable sweep.** Gordon Swanborough. *Chartered Mechanical Engineer*, vol. 18, Mar. 1971, p. 86-93.

The most promising of the current studies aimed at providing a civil airliner with V/STOL characteristics are examined, including the rotor-lift aircraft, powered-lift aircraft, aerodynamic lift aircraft, and variable-sweep aircraft. Problems concerning the pivot in the variable-sweep aircraft are discussed taking into consideration the actually developed aircraft types. The joint 'Panavia' Anglo-German-Italian program for developing a military aircraft and the advanced supersonic bomber project for the USAF are briefly discussed. Z.W.

**A71-24851 \* #**      **Predictions of vortex-lift characteristics by a leading-edge suction analogy.** Edward C. Polhamus (NASA, Langley Research Center, Subsonic Aerodynamics Branch, Hampton, Va.). (*American Institute of Aeronautics and Astronautics, Annual Meet-*

ing and Technical Display, 6th, Anaheim, Calif., Oct. 20-24, 1969, Paper 69-1133.) *Journal of Aircraft*, vol. 8, Apr. 1971, p. 193-199. 28 refs.

A leading-edge suction analogy has been used to develop analytical methods of predicting the low-speed lift and drag-due-to-lift characteristics of sharp-edge delta and delta related wing planforms. In addition, the method has been extended to supersonic speeds, and correlations were made with experimental data. From the results, it appears that the leading-edge suction analogy accurately predicts the lift and drag-due-to-lift characteristics for conditions where essentially complete flow reattachment occurs inboard of the leading-edge vortices. For delta wings, the analogy indicates that the vortex lift is relatively independent of aspect ratio in the range of usual interest. The application of the analogy to nondelta wings has indicated that for the flow reattachment condition, arrow and double delta planforms produce greater values of vortex lift than the delta. Extension of the analogy to supersonic speeds provides a method which appears to accurately predict the reduction in vortex lift with increasing Mach number. (Author)

**A71-24853 # Effects of density ratio on rotary jet flow induction.** J. D. McBayer (Washington University, Cahokia, Ill.) and K. H. Hohenemser (Washington University, St. Louis, Mo.). *Journal of Aircraft*, vol. 8, Apr. 1971, p. 208-212. 6 refs.

Rotary jet flow induction has been considered as a simple means of jet thrust augmentation for VTOL aircraft or other jet propelled vehicles. In potential applications, the primary gas, when expanded to ambient pressure, usually has lower density than the secondary air with which it interacts. Previous analysis has indicated improvements in flow induction for low primary to secondary gas density ratios, however no substantiating tests were available. The present study fills this gap. Experiments have been conducted with a rotary jet device using as the secondary medium ambient air and as the primary medium either helium, a helium-nitrogen mixture, or air, thus covering a range of primary to secondary flow density ratios from 1:7 to 1:1. Substantially smaller improvements of secondary flow induction with lower primary gas density were found than could be predicted with the previous analysis. A revised analysis was correlated with the test results and indicated that with lower primary gas density increasing flow mixing must occur before the process of mutual flow deflection takes place, thereby reducing the effectiveness of rotary jet flow induction for low primary to secondary flow density ratio. Optimum thrust augmentation is obtained for density ratios of about 1:3. (Author)

**A71-24854 # Engine compatibility programs for the supersonic transport propulsion system.** J. B. Taylor (General Electric Co., Supersonic Transport Dept., Cincinnati, Ohio). (*American Institute of Aeronautics and Astronautics, Annual Meeting and Technical Display, 5th, Philadelphia, Pa., Oct. 21-24, 1968, Paper 68-993.*) *Journal of Aircraft*, vol. 8, Apr. 1971, p. 213-218.

Review of the status of the more significant inlet-engine-airframe compatibility programs for SST systems. To date, most of the testing effort has been on inlet-engine compatibility and exhaust nozzle installation effects. Future testing, however, will devote more attention to the airframe effects. The reason for this is that supersonic flight greatly increases the number of propulsion system interactions with the airframe, and places greater demands on the installed propulsion system for higher component and overall efficiency. P.v.T.

**A71-24855 # Inlet dynamics and compressor surge.** Ronald A. Mays (Boeing Co., Commercial Airplane Group, Seattle, Wash.). (*American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 5th, U.S. Air Force Academy, Colorado Springs, Colo., June 9-13, 1969, Paper 69-484.*) *Journal of Aircraft*, vol. 8, Apr. 1971, p. 219-226. 9 refs.

Numerical solution of the one-dimensional, unsteady, inviscid flow equations in a variable area duct, based on Lax's artificial

viscosity technique and developed to examine large-amplitude transients, such as compressor surge, and their effect on mixed-compression inlet flow. The advantages and characteristics of the numerical method are briefly outlined. How to properly define surge, the appropriate numerical boundary conditions, and the sensitivity of inlet flow history to the surge-initiating mechanism are discussed. Representative experimental data are evaluated and compared with numerical results. (Author)

**A71-24856 # Attenuation of inlet flow distortion upstream of axial flow compressors.** G. M. Callahan (United Aircraft Corp., Pratt and Whitney Aircraft Div., West Palm Beach, Fla.) and A. H. Stenning (Lehigh University, Bethlehem, Pa.). (*American Institute of Aeronautics and Astronautics, Propulsion Joint Specialist Conference, 5th, U.S. Air Force Academy, Colorado Springs, Colo., June 9-13, 1969, Paper 69-485.*) *Journal of Aircraft*, vol. 8, Apr. 1971, p. 227-233. 6 refs.

Linearized analysis predicting the velocity and static pressure redistribution in a distorted flow field upstream of a low hub-tip ratio axial flow compressor as a function of the slope of the compressor pressure rise vs mass flowrate characteristic. The attenuation of axial velocity distortion and the magnitude of the generated circumferential and radial velocities are found to increase with a steeper negative slope of the compressor characteristic. Analytical results indicate that the magnitude of the upstream flow redistribution is approximately halved when radial velocities are conserved within the compressor as compared to the results assuming that radial velocities are suppressed within the compressor. The compressor tested suppressed internal radial velocities, and data verified the appropriate analysis. The local slope of the distorted characteristic was found to be significantly less than the undistorted slope. Much of the difference between the local distorted slope and the undistorted compressor characteristic slope was attributable to rotor unsteady effects. (Author)

**A71-24857 # Power-on channel wing aerodynamics.** Edward F. Blick (Oklahoma University, Norman, Okla.) and Vincent Homer. *Journal of Aircraft*, vol. 8, Apr. 1971, p. 234-238. 10 refs.

A theory is developed for lift developed by semicircular channel wings with a pusher propeller at the trailing edge. The theory assumes that the lift on the inside (or top) of a channel airfoil can be determined by using standard airfoil pressure coefficient data but with an effective freestream velocity and an effective freestream static pressure equal to those values just in front of the propeller plane. The lift on the outside (or bottom) of a channel airfoil is assumed to be the same as that calculated by present-day standard methods. Good correlation was found between the theory and wind-tunnel and flight-test data. Both the theory and test data indicate extremely large values of lift coefficient can be obtained with channel wings. (Author)

**A71-24858 \* # Flight path optimization with multiple time scales.** Henry J. Kelley (Analytical Mechanics Associates, Inc., Jericho, N.Y.). *Journal of Aircraft*, vol. 8, Apr. 1971, p. 238-240. 7 refs. Contract No. NAS 12-656.

Approaches involving the asymptotic expansion in several parameters are used in the optimization study. The decoupling of a high-order three-dimensional aircraft flight problem into several lower-order problems is discussed taking into account the possibility of further extension of the approach to rigid body and control-motion problems which take place on additional faster time scales. The problem of a reduced system involving optimal steady flight is considered, and the sublayer system is examined giving attention to aspects of energy interchange. G.R.\*

**A71-24859 # Constrained gain problem and its application to aircraft control systems.** S. J. Asseo (Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y.). *Journal of Aircraft*, vol. 8, Apr.

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1971, p. 241-247. 12 refs.

The objective of the constrained gain problem is to find optimal gains that satisfy given constraints and minimize a quadratic cost functional of the states. The conditions for optimality are obtained by using the calculus of variations. It is shown that the optimal gains yield a stable closed-loop system and locally minimize the cost functional. An algorithm for the iterative solution of optimal gains is presented and the theory is applied to two aircraft control problems where a comparison is made between present results and those of linear optimal control. (Author)

**A71-24861 # An all turbofan VTOL or STOL intercity transport.** T. Gardner Hill (Lockheed-Georgia Co., Marietta, Ga.). *Journal of Aircraft*, vol. 8, Apr. 1971, p. 254-257. 10 refs.

Lift engine technology is examined giving attention to the introduction of the high bypass turbofan lift engines. The effect of the high bypass fan on weight and fuel consumption is a small reduction in engine thrust to weight ratio, and a marked reduction in specific fuel consumption. A graph is provided showing the ratio of lift engine thrust to the weight of the lift engines plus their fuel as a function of bypass ratio for various hover times. Factors responsible for noise reduction in the new engines are examined. Questions of the appropriate location for the lift engines on the aircraft are investigated, and the design of a 100 passenger intercity transport is discussed. Problems of propulsion exhaust scheduling and aircraft interior design are explored. G.R.

**A71-24862 # Development of a double-oblique-shock scramjet model in a shock tunnel.** I. T. Osgerby, H. K. Smithson, and D. A. Wagner (ARO, Inc., Arnold Air Force Station, Tenn.). *Journal of Aircraft*, vol. 8, Apr. 1971, p. 258-263. 12 refs.

A double-oblique-shock scramjet has been developed using the AEDC-VKF 16-in. Shock Tunnel I at a freestream Mach number of 11. The model was developed as a test bed for the development of instrumentation and hydrogen fuel injection techniques for supersonic combustion experiments to be conducted at the 54-in. test section in the AEDC-VKF Tunnel F. Difficulties were encountered, especially at the entrance to the combustor because of the combined action of separation and the interaction of the second shock from the cowl lip. Satisfactory, repeatable performance was obtained with a porous metal inlet ramp to remove the low momentum portion of the inlet boundary layer. The highest total pressure recovery in the combustor was obtained with the porous inlet ramp installed. The measured pressure levels were approximately 50% less than the values predicted for inviscid two-shock performance. The primary pressure losses were attributed to viscous-inviscid flow interactions at the combustor entrance and secondary pressure losses were due to source flow effects in the conical tunnel nozzle flow. (Author)

**A71-24863 # Transonic flight and wind-tunnel buffet onset investigation of the F-8D aircraft.** E. K. Damstrom and J. F. Mayes (LTV Aerospace Corp., Dallas, Tex.). (*American Institute of Aeronautics and Astronautics, Fighter Aircraft Conference, St. Louis, Mo., Mar. 5-7, 1970, Paper 70-341.*) *Journal of Aircraft*, vol. 8, Apr. 1971, p. 263-270. 8 refs.

Results of flight and wind tunnel tests of the F-8D aircraft conducted within Mach 0.72 to 0.92 to establish the proper interpretation of various wind tunnel data in predicting flight buffet onset. The divergence of the rms wing bending moment fluctuation agreed best with the flight onset defined by plus or minus 0.05 peak-to-peak fluctuation of normal acceleration at the center of gravity. Buffet onset trimmed lift coefficient was increased approximately 0.08 when plus or minus 0.05 normal acceleration fluctuation at the pilot station, rather than center of gravity, was

used to define flight onset. The flight test data analysis disclosed an interesting decrease of the predominant frequency of acceleration fluctuation with increasing trimmed lift coefficient during the maneuver. Analysis of flight data suggested that the g level, as well as frequency and amplitude of g fluctuation, should be considered if buffet intensity is to be related to pilot functional capability. A.B.K.

**A71-24864 # Theories on the mechanics of tires and their applications to shimmy analysis.** R. L. Collins (Louisville, University, Louisville, Ky.). *Journal of Aircraft*, vol. 8, Apr. 1971, p. 271-277. 11 refs.

Some theories on tire mechanics and wheel shimmy are discussed and their results compared in an effort to clarify uncertainties as to the validity of the theories. Of particular interest is the comparison of the stretched string and the point contact theories of the mechanics of tires. Contrary to conclusions of some previous investigations, it is found that either of these fundamental, linear theories will predict the shimmy characteristics of wheeled systems if the parameters involved are properly chosen. Nonelastic effects and tire slippage can be and should be included in either theory if further improvement is desired. A simple but important correlation between certain of the parameters of these two basic tire mechanics theories is also demonstrated. The theories are compared with each other and with experimental data. (Author)

**A71-24865 # A slanted round jet at low forward speed.** T. Strand (Air Vehicle Corp., San Diego, Calif.). *Journal of Aircraft*, vol. 8, Apr. 1971, p. 278, 279. Contract No. DA-31-124-ARO(D)-311.

A jet wind-tunnel model consisting of a 3-in. diam nozzle bolted to a plenum chamber is considered. The nozzle and the plenum chamber can be rotated in pitch to vary the jet angle of attack. Flow phenomena associated with a jet in a cross flow are discussed giving attention to the inviscid-flow Trefftz-plane solution reported by Levinsky et al. (1969). Calculated and measured lift at approximately constant mass flow are compared. G.R.

**A71-24866 # An explicit formula for additive drag of a supersonic conical inlet.** Frank W. Barry (United Aircraft Corp., Hamilton Standard Div., Windsor Locks, Conn.). *Journal of Aircraft*, vol. 8, Apr. 1971, p. 279, 280.

It is pointed out that the approach used by Mascitti (1966) for computing the additive drag has the disadvantage of requiring a knowledge of the conical flowfield between the conical shock and the inlet lip. A formula which requires a knowledge of the flow only in the freestream and through the conical surface intersecting the inlet lip with the apex at the tip of the conical centerbody is discussed. G.R.

**A71-24867 # Wave structure of exhaust from transonic aircraft.** Allen E. Fuhs (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio). *Journal of Aircraft*, vol. 8, Apr. 1971, p. 280, 281. 5 refs.

The geometry of the reflection at a shear layer is examined and the train of shock diamonds that occur from an underexpanded jet is considered. It is pointed out that the periodic jet structure requires a negative reflection coefficient. The streamline dividing the jet from the ambient air stream for a periodic and a nonperiodic jet is investigated. A map of the different regions for the reflection coefficient is presented. G.R.

**A71-24868 # Development of a gliding guided ribbon parachute for transonic speed deployment.** William B. Pepper and Ira T. Holt (Sandia Laboratories, Albuquerque, N. Mex.). *Journal of Aircraft*, vol. 8, Apr. 1971, p. 281, 282. AEC-supported research.

A guided parachute system not limited to low-speed deployment is considered. Investigations for modifying conventional ribbon parachutes to provide a glide and turn capability without materially affecting opening reliability, structural integrity, or effective drag are discussed. Design involving two glide flaps are described. Wind-tunnel tests were conducted to investigate gliding performance and radio-controlled flights were made using two motors to open and close the flaps on command. G.R.

**A71-24869 # Calculation of supersonic compressor losses.** W. R. Wells and W. Tabakoff (Cincinnati, University, Cincinnati, Ohio). *Journal of Aircraft*, vol. 8, Apr. 1971, p. 282-284. 10 refs. Grant No. DA-HC-04-69-C-0016.

An attempt is made to supplement previously employed analyses with a semiempirical performance estimation that is believed to be simpler in application and more widely applicable to a large family of cascade geometries. The method discussed extends a successful formulation developed for subsonic compressors by Losey and Tabakoff (1967) to the cases of supersonic compressors in which shock losses are present and accounted for. Other effects, such as dump losses, and errors in the shock structure model used, are partially accounted for through the use of the experimental data. G.R.

**A71-24870 # Optimal stochastic control and aircraft gust alleviation.** Ronald A. Hess (U.S. Naval Postgraduate School, Monterey, Calif.). *Journal of Aircraft*, vol. 8, Apr. 1971, p. 284-286. 6 refs.

The problem of minimizing the mean square normal acceleration of the center of mass of a large, rigid, jet transport flying level through a one-dimensional, turbulent upwash field is considered. In particular, the dependence of the mean square performance and optimal control system gains upon the gust characteristic length is discussed. The strength of this dependence determines the utility of an on-line measurement of the gust characteristic length for the purposes of implementing an adaptive control policy. G.R.

**A71-24871 # Center deflections of square plates with elastic edge beams.** James Ting-Shun Wang (Georgia Institute of Technology, Atlanta, Ga.). *Journal of Aircraft*, vol. 8, Apr. 1971, p. 286, 287.

The sidewall of a typical C-5A cargo box subjected to statically equivalent uniformly distributed inertia load during aircraft maneuvering is considered. All materials are assumed to be elastic. The center deflection that represents the maximum deflection is investigated, and an engineering method for estimating this deflection is discussed. The solutions presented are not exact but are adequate for practical applications. G.R.

**A71-24872 # High speed photographic assembly SFR-2MT with a turbine drive (Vysokoskorostnaia fotograficheskaya ustanovka SFR-2MT s turbinnyim privodom).** A. S. Dubovik, S. N. Sidorov, and S. V. Baranov (Akademiya Nauk SSSR, Institut Fiziki Zemli, Moscow, USSR). *Zhurnal Nauchnoi i Prikladnoi Fotografii i Kinematografii*, vol. 16, Jan.-Feb. 1971, p. 9-14. 8 refs. In Russian.

The assembly consists of a camera, a control panel, and a trigger and has a turbine drive with a scanning mirror, two bearings, a sensor, and a vacuum case. The peak angular velocity of the mirror is 240,000 rpm, the photorecorder scanning rate is a maximum 12,000 m/sec, the resolution is 3 nanosec, and the frame frequency is 8 million frames per sec. The assembly was designed in 1967 as a more advanced modification of the older assembly, SFR-2M, and can perform either continuous recordings or frame photography. V.Z.

**A71-24897 Theory and design of automatic control systems for flight vehicles. Number 1 - Dynamics of linearized**

**automatic control systems (Teoriya i proektirovanie sistem avtomaticheskogo upravleniya letatel'nykh apparatami. Number 1 - Dinamika linearizovannykh sistem avtomaticheskogo upravleniya).** Edited by B. N. Petrov. Moscow, Izdatel'stvo Mashinostroenie (*Moskovskii Aviatsonnyi Institut, Trudy*, no. 189), 1970. 211 p. In Russian.

The topics include: the dynamics of stationary and non-stationary linearized automatic control systems; theoretical studies of processes in systems with deterministic and random inputs; methods of analyzing the stability of processes; synthesis methods; methods of solving equations of free and forced oscillations; response of stationary nonlinear systems to periodic inputs; calculation of input signal distributions for stationary systems in the presence of a non-Gaussian process, and transfer functions characterizing velocity and altitude control for an aircraft employing automatic thrust control. V.P.

**A71-24910 # Certain features of the transfer functions characterizing the speed- and altitude-control modes of an aircraft having a thrust controller (Nekotorye osobennosti peredatochnykh funktsii, kharakterizuiushchikh rezhimy regulirovaniia skorosti i vysoty poleta samoleta s avtomatom tiagi (AT)).** A. I. Egorov. In: *Theory and design of automatic control systems for flight vehicles. Number 1 - Dynamics of linearized automatic control systems (Teoriya i proektirovanie sistem avtomaticheskogo upravleniya letatel'nykh apparatami. Number 1 - Dinamika linearizovannykh sistem avtomaticheskogo upravleniya).* Edited by B. N. Petrov. Moscow, Izdatel'stvo Mashinostroenie (*Moskovskii Aviatsonnyi Institut, Trudy*, no. 189), 1970, p. 172-188. In Russian.

The transfer functions characterizing the speed and altitude parameters of flight are analyzed for an aircraft having an automatic controller which regulates the engine thrust as a function of flight velocity. A system of equations is derived which describes the motion of the aircraft's center of gravity. The coefficients of differential equations comprising this system characterize the aircraft's aerodynamics, engine thrust, inhomogeneity of the atmosphere, and the flight regime. It is shown that the automatic thrust controller provides an aperiodic stability margin for the motion of the aircraft's center of gravity. A stable aircraft with an astatic thrust controller does not have residual deviations in speed and altitude under the action of atmospheric disturbances. T.M.

**A71-24915 On aerodynamic infrasound.** W. C. Meecham (California, University, Los Angeles, Calif.). *Journal of Atmospheric and Terrestrial Physics*, vol. 33, Feb. 1971, p. 149-155. 14 refs. USAF-supported research.

We consider atmospheric pressure variations in the period range from a few seconds to a few minutes. These pressure fluctuations arise (1) from local hydrodynamic effects which are estimated; (2) from nonpropagating pressure effects associated, for example, with a jet stream; (3) from nonpropagating pressure effects associated with aerodynamic infrasound. Following standard aerosonic theory, which is briefly reviewed here, the intensity of aerodynamic sound is estimated. The estimated amount of power radiated by aerodynamic sources, chiefly fluctuating winds at high altitude, is approximately that observed in noise measurements on the ground. Comparison is made between these theoretical estimates and observed pressure fluctuations in the low frequency range. (Author)

**A71-24944 A design of sonic nozzle for the precise measurement of mass flow.** John E. Green (Royal Aircraft Establishment, Bedford, England). *Zeitschrift für Flugwissenschaften*, vol. 19, Mar. 1971, p. 129-137. 16 refs.

A profile form is developed for a family of axisymmetric, convergent-divergent nozzles particularly well suited to the accurate measurement of mass flow rate. The nozzles have very gentle longitudinal curvature, and are for operation in a choked, insulated condition from a uniform air supply. The profile of the nozzles is

such that the axial velocity distribution given by one-dimensional gas dynamics leads to an exact analytic solution of the laminar boundary equations, derived by a transformation of the well-known solution for two-dimensional, incompressible sink flow. For a model gas, with Prandtl number unity and viscosity proportional to temperature, the solution for the transonic region as a whole is exact in the limit of infinite Reynolds number and vanishing throat curvature. The departures from this exact solution, when the gas is air and the Reynolds number and throat curvature have values which might be expected under laboratory conditions, are examined, the most serious potential sources of error in determining mass flow are discussed, and some means of keeping these errors to a minimum are suggested. (Author)

**A71-24945**      **Determination of the thickness distribution of propeller blade profiles at a given pressure distribution (Bestimmung der Dickenlinie von Propellerflügelprofilen bei vorgegebener Druckverteilung).** Ralf Hille (Hamburg, Universität, Hamburg, West Germany). *Zeitschrift für Flugwissenschaften*, vol. 19, Mar. 1971, p. 138-143. In German. Research supported by the Deutsche Forschungsgemeinschaft.

If the pressure field of a screw propeller in a stationary potential flow and the hydrodynamic pitch  $k$  sub 1 are known, it is possible to calculate the thickness distribution and the camber line of the hydrofoil. This requires the determination of the source-sink distribution and the vorticity distribution and leads in the scope of a linearized theory to an integral equation with a singular kernel function which is discussed and solved for a propeller with sector type blades. This integral equation remains essentially unchanged if the nonlinear problem is approximately treated by an iteration process. (Author)

**A71-24946**      **Theory of three techniques for determining parameters of an elastomechanical system in ground vibration testing (Theorie dreier Verfahren zur Bestimmung der Parameter eines elastomechanischen Systems im Standschwingungsversuch).** Hans Georg Küssner (Aerodynamische Versuchsanstalt, Göttingen, West Germany). *Zeitschrift für Flugwissenschaften*, vol. 19, Feb. 1971, p. 53-61. 8 refs. In German.

Three methods for performing and evaluating ground vibration tests used for determining elastomechanical parameters of aircraft are theoretically examined and discussed: the integral equation technique, the phase resonance technique, and the phase separation technique. The advantages and disadvantages of these techniques and fields of their applicability are discussed. O.H.

**A71-24947**      **Gust load of a plane rigid airfoil using an exact and approximated solution (Böenbeanspruchung des ebenen starren Tragflügels bei exakter und genäherter Rechnung).** Hermann Stümke (Stuttgart, Universität, Stuttgart, West Germany). *Zeitschrift für Flugwissenschaften*, vol. 19, Feb. 1971, p. 76-80. 5 refs. In German.

The author's previously proposed method of the 'asymptotic' equivalent oscillatory model is applied to the problem of the motion of a plane rigid airfoil with the fixed center of gravity in turbulent air. Compared with the exact nonsteady theory, this method involves a certain overestimation of the gust load which, however, does not exceed 20% in the area of the major interest. On the other hand, the quasi-steady theory by Glauert (1928) leads in general to essentially larger deviations from the results of the exact theory. O.H.

**A71-24949**      **The tensor of inertia and the products of inertia in aircraft (Über den Trägheitstensor und die Deviationsmomente von Flugzeugen).** Ernst Mewes and Gerhard Rosenau (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Institut für Flugmechanik, Braunschweig, West Germany). *Zeitschrift für Flugwissenschaften*, vol. 19, Feb. 1971, p. 81, 82. In German.

In defining the tensor of inertia, the moments of inertia (elements in the principal diagonal) are positive, whereas the products of inertia (elements beyond the principal diagonal) can be either positive or negative. Formulas are given for a conversion from the principal system of coordinates to a system rotated by an angle for the case that the y-axis is the principal axis of inertia. It is found that the products of inertia are negative in this particular case. O.H.

**A71-24952** #      **Aerodynamic noise caused by a flow past rigid bodies (Aerodynamický zvuk při obtékání pevných těles).** Jiří Šulc. *Zpravodaj VZLÚ*, no. 4, 1970, p. 7-26. 23 refs. In Czech.

Discussion of the mechanism responsible for the generation of aerodynamic noise by a subsonic flow of a gaseous medium in the presence of rigid surfaces. Based on Lighthill's theory, functions defining the dependence of fundamental acoustic parameters on flow parameters are formulated for several rigorously defined cases. Particular attention is also given to a specific case of noise generation in the turbulent boundary layer in view of its application to the flight of aircraft. A review is given of practical methods for the calculation of the total level of acoustic pressure and its spectral composition caused by the turbulent boundary layer on the surface of aircraft. Finally, results of the author's own measurements are presented and summarized in a form suitable for the determination of the lowest approximate probable value of cabin noise caused by the turbulent boundary layer for some types of aircraft. O.H.

**A71-24953** #      **The lift correction in a perforated two-dimensional experimental wind tunnel (Oprava na vztlak v perforovaném dvourozměrovém měřicím prostoru).** Jiří Benetka. *Zpravodaj VZLÚ*, no. 4, 1970, p. 27-34. 8 refs. In Czech.

Perforated walls of two-dimensional transonic wind tunnels change the shape of the streamlines in their neighborhood and thus influence the entire flowfield in the tunnel. The correction of both the angle of incidence and the aerodynamic coefficients caused by the change of the streamline curvature around an airfoil model in a perforated tunnel is derived. This correction is of the same order as the upwash correction and therefore creates a significant part of the corrections necessary in a perforated two-dimensional wind tunnel. Experimental results are presented which are in good agreement with the theoretically obtained corrections. O.H.

**A71-24954** #      **Modeling of nonstationary stresses in aircraft structures (Modelování nestacionárních napětí v leteckých konstrukcích).** Jan Drexler and Vojtěch Nejedlý. *Zpravodaj VZLÚ*, no. 4, 1970, p. 35-43. 10 refs. In Czech.

Examination of some problems associated with modeling of difficult processes in the area of operation reliability of aircraft components and structures. It is shown that using a special random generator of binomial pulses equipped with a probability transformer, a simple and flexible loading circuit can be designed which enables generation of a wide class of nonstationary stochastic stress processes with a priori prescribed probability distributions. A theoretical calculation of a procedure for adjusting the parameters of the probability changer in order to obtain the required statistical distributions is presented. The results of this calculation are compared with experimental data obtained in a fatigue test of the lower arm of a landing gear break strut of a jet trainer. O.H.

**A71-24958** #      **Model investigations of subsonic stages of an axial compressor.** Karel Čelíkovský. *Zpráva VZLÚ*, Dec. 1970, p. 1-51. 30 refs.

Discussion of some results of extensive theoretical and experimental research on a series of model compressor blades designed according to available technical literature. The method used for calculating isolated stages is presented and verified. The stages were treated as moderately aerodynamically loaded and subsonic. The

outer dimensions and the degree of aerodynamic loading were almost identical throughout the series investigated; the hub-tip ratio, however, was systematically decreased until it reached for the last stage of the experimental series a value employed in designing front-fan turbojets by the world's leading producers. The characteristics of the stages investigated are discussed and compared with a thermodynamic calculation. O.H.

**A71-24963** Influence of the weather on long range radio navigational aids (Influenza del tempo sull'assistenza radioelettrica alla navigazione a lungo raggio). Carlo Torriani. *Rivista Aeronautica*, vol. 46, Dec. 1970, p. 2095-2146. In Italian.

Consideration of the principles upon which various long range navigational systems are based, with discussion of their characteristics. The GEE, LORAN, and DECCA systems, developed during WW II and after, are briefly outlined. Methods of navigation which use polar coordinates (Consol, Omiranges) are considered. The effects of radio paths, subsidence, advection, clouds, and various types of winds are described. The influence of atmospheric conditions on radiotransmission in general, and on various navigation systems in particular is considered in detail. Supersonic aircraft operation and principles of inertial navigation are treated. F.R.L.

**A71-24997** Aircraft and the bird hazard. G. W. Underwood (Hawker Siddeley Aviation, Ltd., Kingston-upon-Thames, Surrey, England). *Environmental Engineering*, Mar. 1971, p. 13-18.

The results of a general aircraft survey regarding bird impact problems are discussed. It was found that the distribution of known strikes on aircraft was roughly proportional to the frontal area. All parts of forward facing structural area were vulnerable to major damage on many current civil and military aircraft. Most strikes were at a relatively low level and very few occurred above 5000 ft. While fatal accidents have been relatively few, many cases would appear to have occurred where major disasters have been avoided more by luck than by the presence of bird impact-proof structures. Structural integrity requirements in relation to bird strike are examined, and methods for alleviating the hazard are discussed. The development of test techniques for aircraft structures is considered, and some current research for providing design information is reported. G.R.

**A71-25015** Use of the coupling of airfoil sections method as a means of studying the general movement of an obstacle in an ideal fluid in the presence of a rectilinear wall (Sur la méthode du couple des profils pour l'étude du mouvement général d'un obstacle dans un fluide idéal en présence d'une paroi rectiligne). Titus Petrila (Cluj, Universitatea, Cluj, Rumania). *Académie des Sciences (Paris), Comptes Rendus, Série A - Sciences Mathématiques*, vol. 272, no. 12, Mar. 22, 1971, p. 818-821. In French.

Development of a new method, similar to that of Capodanno (1966), which makes it possible to solve for the general case the problem of the determination of the complex potential of a plane fluid flow produced by the movement of an arbitrary airfoil section in the presence of a fixed infinite rectilinear wall. The fluid is assumed to be ideal and incompressible, and at rest at infinity. The problem at the limits set in the plane of the circular crown is also solved. F.R.L.

**A71-25052** # Structural response to sonic booms. Roland L. Sharpe (John A. Blume and Associates, Engineers, San Francisco, Calif.). (American Society of Civil Engineers, National Structural Engineering Meeting, Portland, Ore., Apr. 6-10, 1970.) *American Society of Civil Engineers, Structural Division, Journal*, vol. 97, Apr. 1971, p. 1157-1174. 6 refs. FAA-USAF-sponsored research.

Extensive research was carried out to investigate the dynamic loading of structures which results from shock waves created by aircraft flying at supersonic speeds. The results show that properly designed and constructed houses should incur either no or only a minor damage. A large percentage (55 to 80%) of all damage incidents is glass damage. Plate and racking deflections in typical houses from sonic booms with 1 psf to 2 psf overpressure are small and on the order of 0.034 in. and 0.005 in., respectively. Sonic booms from large aircraft affect a larger range of structure elements than those from smaller aircraft. The response to sonic booms can be adequately predicted if the characteristics of the boom and structure elements are known. Free field signatures can be used to adequately predict structure response. Structure response prediction can be greatly simplified by use of a boom pressure wave model. O.H.

**A71-25085** # An investigation of the forces on flat plates normal to a turbulent flow. P. W. Bearman (Ministry of Technology, National Physical Laboratory, Teddington, Middx., England). *Journal of Fluid Mechanics*, vol. 46, Mar. 15, 1971, p. 177-198. 8 refs.

Measurements on square and circular plates in turbulent flow show the mean base pressure to be considerably lower than that measured in smooth flow. Power spectral density measurements of the fluctuating component of the drag on square plates in both smooth and turbulent flow are presented. The measurements in turbulent flow show the importance of the ratio of turbulence scale to plate size. There is shown to be a strong correlation between the fluctuating drag force and the velocity fluctuations in the approaching flow. The distortion of the turbulence structure approaching a plate is also discussed. (Author)

**A71-25096** The hypersonic boundary layer on a wedge with uniform mass addition and viscous interaction. W. S. King and R. L. Varwig (Aerospace Corp., El Segundo, Calif.). *International Journal of Heat and Mass Transfer*, vol. 14, Jan. 1971, p. 41-48. 13 refs. Contract No. AF 04(701)-69-C-0066.

Analytical and experimental investigation of the effects of uniform surface blowing on the hypersonic boundary layer with viscous interaction. For strong and moderate viscous interaction, the heat transfer on a flat plate and a slender wedge is calculated by use of the local similarity technique to solve the boundary layer equations and by the tangent wedge approximation to determine the inviscid pressure. The experiments are conducted at Mach numbers of 16 and 20, at unit Reynolds numbers of 230,000 and 130,000 per ft, and at the cold wall condition. The analytical and experimental results are in good agreement. For moderate blowing, it is found that the effects of viscous interaction dominate the flow when the interaction is strong and that the effects of blowing become more important as the strength of the viscous interaction decreases. (Author)

**A71-25097** Approximate calculation of heat- and mass-transfer in supersonic laminar boundary layers blown with a light gas (Näherungsweise Berechnung des Wärme- und Stoffaustausches in laminaren Ueberschallgrenzschichten bei ausblasen eines leichten Gases). J. L. Bansal (Aerodynamische Versuchsanstalt, Göttingen, West Germany). *International Journal of Heat and Mass Transfer*, vol. 14, Jan. 1971, p. 83-131. 29 refs. In German.

A general solution for a binary-mixture boundary layer is obtained under the assumption that the fluid properties are variable and that the Prandtl and Schmidt numbers are arbitrary and are functions of the concentration. The method employed is derived from an analysis of the influence of blowing a cooling agent into a supersonic boundary layer, in the case where the parameters of the blowing gas differ from those of the external flow. The approximate results are obtained in closed form, which makes them applicable for studying parameter variations even in cases that do not lend themselves to numerical analysis. V.P.

## A71-25132

**A71-25132**      **U.S. General Aviation safety record.** C. O. Miller, Paul Alexander, and Starke Jett (U.S. Bureau of Aviation Safety, Department of Transportation, Washington, D.C.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710397.* 35 p. 10 refs. Members, \$1.00; nonmembers, \$1.50.

The General Aviation safety record through 1970 is discussed, both statistically and in the nonquantitative sense. Related functions of the cognizant aviation accident investigatory agency, the National Transportation Safety Board, are also reviewed to place the data in proper perspective. Finally, a matrix is provided as an outline for participants in the General Aviation system to assess their own contribution to accident/injury prevention in this most rapidly growing segment of aviation. (Author)

**A71-25133**      **FAR 23 fatigue substantiation procedures - GAMA committee report.** R. D. Christian (North American Rockwell Corp., Aero Commander Div., Bethany, Okla.). *Society of Automotive Engineers, National Business Aircraft Meeting, Wichita, Kan., Mar. 24-26, 1971, Paper 710403.* 28 p. 15 refs. Members, \$1.00; nonmembers, \$1.50.

Recommended fatigue evaluation procedures for demonstrating compliance with new FAA regulations concerning the fatigue of aircraft wings. Typical test load spectra are illustrated for simulations of gust loads, maneuver loads, ground-air-ground effects, taxi loads, and landing impact loads. The proper use of S-N curves for endurance data is demonstrated, and appropriate scatter factors are established. The use of automatic fatigue monitoring devices under operational conditions is briefly considered. T.M.

## STAR ENTRIES

**N71-19353#** Advisory Group for Aerospace Research and Development, Paris (France).

### **AERODYNAMIC INTERFERENCE**

Jan. 1971 451 p refs Presented at Fluid Dyn. Panel Specialists' Meeting, Silver Spring, Md., 28-30 Sep. 1970

(AGARD-CP-71-71) Avail: NTIS HC\$6.00/MF\$0.95

Aerodynamic interference characteristics of various airframe-propulsion systems for commercial transport and military aircraft are discussed. Wing-fuselage store designs and body-wing and tail configuration effects are emphasized.

**N71-19354#** Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.

### **SOME REMARKS ON THE INTERFERENCE BETWEEN A SWEEP WING AND A FUSELAGE**

D. Kuechemann *In* AGARD Aerodyn. Interference Jan. 1971 11 p refs

Avail: NTIS HC\$6.00/MF\$0.95

Principal physical interference effects which occur when a swept (or unswept) wing is joined to a fuselage are analyzed. The flow is dominated by what happens in the junction between the two bodies; here the interference is largest. The leading terms in the velocity field can be interpreted as being caused in part by the interference with the mirror image in a plane wall of the half wing outside the fuselage. This reflection effect depends mainly on the sweep angle and the dihedral angle. In addition, there is a body interference effect at all sweep and dihedral angles. The method of singularities is applied to calculate the inviscid flow field for some simple cases with and without lift. Theoretical and experimental results demonstrate quite clearly the magnitude of the interference effect.

Author

**N71-19355#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany).

### **WIND TUNNEL INVESTIGATION OF THE VORTEX SYSTEM NEAR AN INCLINED BODY OF REVOLUTION WITH AND WITHOUT WINGS**

F.-R. Grosche *In* AGARD Aerodyn. Interference Jan. 1971 15 p refs

Avail: NTIS HC\$6.00/MF\$0.95

The flow field on the suction side of a slender body of revolution with and without wings was investigated by means of a directional probe in a 3 m x 3 m low speed wind tunnel. Measurements have been conducted at Mach numbers  $Ma = 0.12$  and Reynolds numbers  $Re = 500,000$ , based on free stream velocity and body diameter. The model was tested at angles of attack  $\alpha = 7$  deg, 10 deg, 15 deg, 20 deg. From the measured data, the cross flow velocities and the isobars of total pressure loss were computed. Position and strength of the vortices were determined as functions of the axial coordinate. There are significant deviations from the results of measurements at high subsonic or supersonic velocities, as well as from measurements at substantially lower Reynolds numbers. The strength of the body vortices is considerably reduced by the presence of the wings.

Author

**N71-19356#** Boeing Co., Seattle, Wash. SST Aerodynamics Configuration Group.

### **CONSIDERATIONS OF AERODYNAMIC INTERFERENCE IN SUPERSONIC AIRPLANE DESIGN**

Edward J. Kane and Wilbur D. Middleton *In* AGARD Aerodyn. Interference Jan. 1971 16 p refs

Avail: NTIS HC\$6.00/MF\$0.95

Methods for optimizing the interferences between aircraft wing and body, wing and engine nacelles, and wing and trimming surfaces in supersonic flow are discussed. Theoretical concepts are reviewed and expanded where necessary to understand the physical relationship that leads to the most favorable arrangement of the configuration components. Specific applications are illustrated by examples employing analyses of both theoretical and experimental data.

Author

**N71-19357\*#** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

### **RECENT EXPERIENCE IN USING FINITE ELEMENT METHODS FOR THE SOLUTION OF PROBLEMS IN AERODYNAMIC INTERFERENCE**

Ralph L. Carmichael *In* AGARD Aerodyn. Interference Jan. 1971 5 p refs

(NASA-TM-X-66884) Avail: NTIS CSCL 20D

Discrete sets of elementary solutions of the linearized equations of gas dynamics for solving problems of flow about airplane configurations are combined in such a way that the boundary conditions of zero flow through physical surfaces are satisfied at large numbers of control points on the surfaces. Calculations using discrete elements and discrete control points produce solutions consistent with closed-form solutions that satisfy the boundary conditions everywhere. An existing computer program for predicting the flow about simple wing-body combinations is expanded to include bodies other than the main fuselage.

Author

**N71-19358#** National Physical Lab., Teddington (England). Aerodynamics Div.

### **THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF WING BODY CONFIGURATIONS AT LOW SUPERSONIC SPEEDS**

J. Bridgewater, R. C. Lock, and G. F. Lee *In* AGARD Aerodyn. Interference Jan. 1971 11 p refs

Avail: NTIS HC\$6.00/MF\$0.95

Wing-body combinations with modifications to the shapes of the basic bodies, wing leading edges and wing roots for reduced drag at transonic and low supersonic speeds were studied. Force and pressure measurements are given for a 55 deg swept wing mounted in turn on two asymmetrically waisted bodies. The first body was designed with the aid of the transonic area rule, and the second was a modified version of this design to give improved performance at low supersonic speeds. Additional experimental results are presented for a second wing having a much blunter leading edge shape so as to give a peaky type of pressure distribution in place of the roof-top pressure distribution of the first wing. Finally considered is the blending of varying wing section shapes near the root of swept wings at supersonic speeds in order to achieve a favorable combined wing-body pressure field inboard on the wind, thus offering the possibility of drag reduction without the use of body waisting.

Author

**N71-19359#** Technische Hogeschool, Delft (Netherlands).

### **LIFT AND DRAG CHARACTERISTICS OF DELTA WING HALF CONE CONFIGURATIONS WITH SUBSONIC LEADING EDGES, USING SLENDER BODY THEORY**

W. J. Bannink and J. W. Reyn *In* AGARD Aerodyn. Interference Jan. 1971 11 p refs

Avail: NTIS HC\$6.00/MF\$0.95

Configurations composed of a cone with a half-circular

cross section mounted asymmetrically with respect to a delta wing of zero thickness with subsonic leading edges and placed in a supersonic flow, are studied using slender body theory. The lift and drag characteristics are compared to those of configurations having an identical wing and a symmetrically disposed circular cone of equal volume as the half cone. A disposition of a half cone on one side of the delta wing shows a drag reduction at a given lift compared to the symmetrical full cone configuration, provided the body diameter-wing span ratio is larger than 0.45 approximately. However, the high wing disposition is preferable to the low wing, since lower angles of incidence are required to attain a certain lift. Below the ratio of 0.45 the symmetrical system appears to be more favorable. The lift curve slopes of asymmetrical configurations studied are larger than those of symmetrical configurations.

Author

**N71-19350#** Messerschmitt-Boelkow G.m.b.H., Munich (West Germany).

**DOWNWASH INVESTIGATIONS ON TAILS OF MISSILES**

G. Gregoriou and J. Laude (DFVLR, Brunswick, West Germany) *In* AGARD Aerodyn. Interference Jan. 1971 14 p refs

Avail: NTIS HC\$6.00/MF\$0.95

A numerical method was developed to calculate the downwash and hence the forces and moments on missile tails. This method is principally based on the linear lifting surface theory and can be applied in the compressible subsonic range at any angle of attack and bank. The results of the calculation indicate a nonlinear dependence of the average downwash angle on the angle of attack. Generally, theoretical results show good agreement with wind tunnel tests.

Author

**N71-19361\*#** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**EXTENSION OF A NUMERICAL SOLUTION FOR THE AERODYNAMIC CHARACTERISTICS OF A WING TO INCLUDE A CANARD OR HORIZONTAL TAIL**

Barrett L. Shrout *In* AGARD Aerodyn. Interference Jan. 1971 12 p refs

(NASA-TM-X-66886) Avail: NTIS CSCL 20D

A method for predicting the aerodynamic lifting surface characteristics of wing-horizontal tail configurations or canard wing configurations at supersonic speeds is discussed. The numerical solution has been programmed for a digital computer and is part of a complex of computer programs used in the design, optimization, and evaluation of aircraft configurations at supersonic speeds. The present method predicts lift, drag, and moment characteristics over a range of lift coefficients and for various control settings. Theoretical and experimental data are compared for wing-horizontal tail configurations and for canard-wing configurations at various Mach numbers. These comparisons show both the basic data with control deflections and some final trimmed drag polars. Some data are also presented to show the extent to which program limitations affect the accuracy of the analytic methods.

Author

**N71-19362#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France).

**CALCULATION OF AERODYNAMIC INTERACTIONS BETWEEN LIFTING ELEMENTS OF AN AIRPLANE IN SUPERSONIC STATIONARY OR NONSTATIONARY FLOW [CALCUL D'INTERACTIONS AERODYNAMIQUES ENTRE LES ELEMENTS PORTANTS D'UN AVION EN ECOULEMENT SUPERSONIQUE STATIONNAIRE OU INSTATIONNAIRE]**

Michel Enselle, Jean-Paul Boisseau, and Andre Guillois *In* AGARD Aerodyn. Interference Jan. 1971 7 p refs *In* FRENCH; ENGLISH summary

Avail: NTIS HC\$6.00/MF\$0.95

After recalling the principle of analog computation of a lifting assembly in supersonic, steady or unsteady flow a numerical

process is presented that uses an explicit method for computing the solutions of the wave equation. Results obtained either by analog or by numerical computations are presented for wing-body or wing-pod interactions, and for a wing of arbitrary planform in unsteady flow.

Author

**N71-19363#** Naval Ship Research and Development Center, Washington, D.C.

**THE EFFECT OF ANGLE OF ATTACK ON INDUCED ROLLING MOMENT FOR A LOW ASPECT RATIO MISSILE**

Raymond P. Le Beau *In* AGARD Aerodyn. Interference Jan. 1971 11 p refs

Avail: NTIS HC\$6.00/MF\$0.95

Two wind tunnel tests were conducted to examine the characteristics of the induced rolling moment of two small span missile configurations at transonic Mach numbers for angles of attack up to 90 deg. The induced rolling moment at a roll angle of 22.5 deg was found to increase with angle of attack to a peak value then remain near that value to 90 deg. This peak occurred at angles between 25 deg and 40 deg. It was also observed that negative values of induced rolling moment at a roll angle of 22.5 deg occurred for one configuration when the angle of attack was less than 20 deg.

Author

**N71-19364#** National Aerospace Lab., Amsterdam (Netherlands). Dept. for Theoretical Aerodynamics.

**AN APPROXIMATE METHOD FOR THE CALCULATION OF THE PRESSURE DISTRIBUTION ON WING BODY COMBINATIONS AT SUBCRITICAL SPEEDS**

Th. E. Labrujere, W. Loeve, and J. W. Slooff *In* AGARD Aerodyn. Interference Jan. 1971 17 p refs

Avail: NTIS HC\$6.00/MF\$0.95

A method is described which makes it possible to calculate accurate pressure distributions on lifting configurations at Mach numbers up to the critical value. The compressible flow around a configuration is related to an incompressible flow by means of Goethert's rule, which is supplemented semi-empirically. The iterative scheme for solving the large system of linear, simultaneous equations that is involved with the incompressible flow problem is optimized. Assuming a simple wake configuration, the method has been applied to a number of lifting wing-body combinations. Comparisons with measured pressure distributions show that the method can be used when studying wing-body interference problems in subcritical, attached flow.

Author

**N71-19365#** Naval Ordnance Lab., White Oak, Md.

**AERODYNAMIC INTERACTION PHENOMENA PRODUCED BY A FIN PROTUBERANCE PARTIALLY IMMersed IN A TURBULENT BOUNDARY LAYER AT MACH 5**

Allen E. Winkelmann *In* AGARD Aerodyn. Interference Jan. 1971 12 p refs

Avail: NTIS HC\$6.00/MF\$0.95

Various flow visualization results are presented for a cylindrically blunted, unswept, unyawed fin partially immersed in a turbulent boundary layer. The model, consisting of a fin-flat plate combination, was mounted on the test plate nozzle wall of a boundary layer channel. Experiments were completed at a nominal Mach number of 5 and nominal free-stream Reynolds numbers per foot of 2.8 x 1 million and 7.4 x 1 million. Azobenzene tests show regions of high heat transfer to occur on the flat plate immediately upstream and downstream of the fin. Oil smear tests show in detail the surface shear directions and locations of separated flow which occur on the model. Schlieren and shadowgraph photographs indicate the complex shock wave structure which exists in front of the fin.

Author

**N71-19366\*#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**FLIGHT AND WIND TUNNEL INVESTIGATION OF**

# **INSTALLATION EFFECTS ON UNDERWING SUPERSONIC CRUISE EXHAUST NOZZLES AT TRANSONIC SPEEDS**

Daniel C. Mikkelsen and Bernard J. Blaha / *In AGARD Aerodyn. Interference* Jan. 1971 10 p refs  
(NASA-TM-X-66887) Avail: NTIS CSCL 20D

A combined flight and wind tunnel test program is being conducted utilizing a modified F-106 aircraft, to investigate airframe installation effects on exhaust nozzle systems mounted on underwing engine nacelles. Flight tests in the transonic speed regime determined nozzle performance and boattail drag for variable flap ejector, conical plug, and auxiliary inlet ejector nozzle concepts. Wind tunnel tests were conducted on isolated models of these nozzles and also on a 1/20-scale model of the F-106 aircraft with simulated underwing engine nacelles. Wing and nacelle pressures from these wind tunnel tests are used to qualitatively explain the observed installation effects. The 1/20-scale model was also used to evaluate the effects of changes in nacelle geometry and angle-of-attack.

Author

**N71-19367#** National Aeronautical Establishment, Ottawa (Ontario).

# **THE HALF CONE PRESSURE FIELD AND ITS SIGNIFICANCE TO SIDE MOUNTED INTAKES**

D. J. Peake, D. J. Jones, and W. J. Rainbird / *In AGARD Aerodyn. Interference* Jan. 1971 12 p refs  
Avail: NTIS HC\$6.00/MF\$0.95

The supersonic, inviscid flow field about an isolated half cone has been computed and the result applied to a semi cone intake mounted adjacent to an aircraft fuselage. The pattern of the intake external flow was obtained from an aircraft model tested in a Mach number  $M = 1.6$  airstream, incorporating a 25-degree semi-angle half cone. The fuselage boundary layer approaching the intake was turbulent, corresponding to a Reynolds number of  $0.8 \times 1$  million based upon the intake capture dimension. The strong, three dimensional character of the interactions that occur between the intake shock system and the fuselage boundary layer imply that any boundary layer control system must be designed to remove the effects of three dimensional rather than two dimensional separations.

Author

**N71-19368#** National Aeronautics and Space Administration, Langley Research Center, Langley, Va.

# **AERODYNAMIC INTERFERENCE BETWEEN EXHAUST SYSTEM AND AIRFRAME**

Jack F. Runckel / *In AGARD Aerodyn. Interference* Jan. 1971 13 p refs

(NASA-TM-X-66888) Avail: NTIS CSCL 01A

Mutual aircraft afterbody and engine nozzle interferences are studied by a model experimental investigations of jet interference at subsonic, transonic, and supersonic speeds. Emphasis is placed on twin-engine fuselage configurations with nozzles installed near the terminus of the afterbody where the interactions of the nozzle exhausts and the external stream produce a complex flow field environment. Airframe interferences on nozzle performance considered are: installation locations in the afterbody, boattailing ahead of the nozzles, and effects of tails and protuberances. Nozzle shape and jet exhaust interference can alter aircraft performance and stability. The effect on afterbody drag of nozzle exit axial location appears to pose more problems than the lateral spacing of the nozzles. For closely spaced nozzles, the shape of the interfairing between the nozzles has a pronounced effect on afterbody and nozzle performance.

Author

# **N71-19369# General Electric Co., Cincinnati, Ohio. AIRFRAME/PROPULSION SYSTEM INTEGRATION ANALYSIS USING THE PROPULSION SIMULATOR TECHNIQUE**

John T. Kutney / *In AGARD Aerodyn. Interference* Jan. 1971 21 p refs

Avail: NTIS HC\$6.00/MF\$0.95

The propulsion simulator technique was conceived to provide the analysis and evaluation of the total system performance in the wind tunnel of the new high bypass turbofan installations. This technique provides simultaneous simulation of the induction system and the exhaust system flows with correct geometric simulation and allows the total aircraft aerodynamics and the propulsion system interactions to be evaluated together without the use of additional or reference models. Examples of these data are presented including comparison of a C5A type scale model and full scale results of the TF39/B52 installation. The use of this technology for advanced programs of airframe engine integration for both the subsonic and supersonic flight spectrums is discussed.

Author

# **N71-19370# Tennessee Univ., Tullahoma, Space Inst. UNSTEADY AERODYNAMICS OF ROTOR BLADES OF A COMPRESSOR UNDER DISTORTED FLOW CONDITIONS**

B. H. Goethert and K. C. Reddy / *In AGARD Aerodyn. Interference* Jan. 1971 13 p refs

Avail: NTIS HC\$6.00/MF\$0.95

A theoretical investigation was undertaken to determine the interference effect between oscillating and distorted inlet flow and compressor stall. It was found that the dynamic effects on the single stage characteristics tend to make the stages less sensitive to pressure oscillations since the flow lacks the necessary time for building up the lift of the individual blades of the stage. On the other hand, the spacer volume in the stages themselves and between the stages produce time lags which tend to increase the stage pressure ratio and thus reduce the stall margin of the individual stages. Depending upon the geometry and the type of oscillations, either the beneficial effects of the dynamic response reduction of individual stages at higher frequencies or the detrimental effects of the spacer volume between the stages will prevail.

Author

**N71-19371#** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

# **STUDIES OF AIRCRAFT FLOW FIELDS AT INLET LOCATIONS**

Lyndell S. King and Terence W. Schmidt (Arnold Res. Organ., Inc.) / *In AGARD Aerodyn. Interference* Jan. 1970 10 p refs

(NASA-TM-X-66885) Avail: NTIS CSCL 20D

A wind-tunnel investigation of the flow fields about fuselage configurations at transonic and supersonic speeds and at angles of attack up to 24 deg is reported. A family of seven fuselages with different cross sectional shapes was tested in conjunction with two nose shapes, two canopies, and two wings of different sweep. Flow field surveys were performed at two likely inlet locations—ahead of and under the wing—to assess the effects of forebody geometry throughout the Mach number and angle-of-attack envelope. The experimental data particularly indicate the strong influence of the canopy, nose droop, and fuselage shape on flow angularities in the forward survey plane. Nose droop and the canopy both tend to reduce sensitivity to positive angles of attack and to reduce the extent of influence of fuselage lower corner geometry. Under the wing, however, the flow field is dominated by the effects of the wing itself.

Author

**N71-19372#** National Gas Turbine Establishment, Pyestock (England).

# **SOME RECENT RESEARCH ON SUPERSONIC INTAKES AT NGTE**

M. C. Neale and F. W. Armstrong / *In AGARD Aerodyn. Interference* Jan. 1971 18 p refs

Avail: NTIS HC\$6.00/MF\$0.95

Drag investigations covering both supersonic and subsonic flight conditions are described, and attention is focused on the difficulty of minimizing supersonic pre-entry drag while retaining an adequate stability margin. The effects are shown of shear planes of varying strength generated in the supersonic compression field.

Reynolds number effects are also described. A brief survey of prospects for mixed compression intakes offering an optimum combination of drag and high pressure recovery in supersonic flight is included. Author

**N71-19373#** Boeing Co., Seattle, Wash. Supersonic Transport Div.

# **CONFIGURATION ASPECTS OF PROPULSION INSTALLATION ON SUPERSONIC TRANSPORTS**

Albert A. Van Duine, William W. Rhoades, and Walter C. Swan *In* AGARD Aerodyn. Interference Jan. 1971 8 p

Avail: NTIS HC\$6.00/MF\$0.95

Intake decision closely related to configuration effects are outlined for supersonic transport applications. The general problems of propulsion pod placement and proper integration of pod and wing are discussed. The effects of wing flow field and aircraft maneuvers on intake performance and intake operating envelope are treated. Intake-to-intake and intake-to-wing spacing criteria are established relative to mutual intake interference and wing/body boundary layer effects. Finally, a propulsion comparison is made between a variable sweep configuration employing double engine pods and a fixed wing configuration employing single engine pods. Author

**N71-19374#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany).

# **JET SIMULATION AND JET INTERFERENCE EFFECTS ON TAILPLANE**

W. Geissler and R. Wulf *In* AGARD Aerodyn. Interference Jan. 1971 12 p refs

Avail: NTIS HC\$6.00/MF\$0.95

Extensive wind tunnel tests with jet simulation have been carried out in the low speed wind tunnel on different models of the European Airbus. Bypass engines able to simulate the correct ratios of jet to freestream velocity have been developed and are described. The results of force and downwash measurements show destabilizing influences of the airplane caused by jet-tailplane interference. Several steps have been undertaken in order to minimize these effects: the displacement of the engines in wing-tip direction seemed to be the best solution of this problem. In addition to force measurements on a complete model the determination of magnitude and direction of the flow velocities established the boundaries of jet influence. Author

**N71-19375#** British Aircraft Corp., Weybridge (England). Aerodynamics Dept.

# **THE COMPLEX AERODYNAMIC INTERFERENCE PATTERN DUE TO REAR FUSELAGE MOUNTED POWERPLANTS**

P. R. G. Williams and D. J. Stewart *In* AGARD Aerodyn. Interference Jan. 1971 15 p ref

Avail: NTIS HC\$6.00/MF\$0.95

The complex interference effects due to rear fuselage mounted power plants on modern high subsonic aircraft are investigated. Results from wind tunnel and full scale flight tests obtained during design and development of BAC VC10 and 1-11 are discussed. Of particular interest are the favorable interference on the wing and comparisons between twin and four-engined configurations. The influences of changes in fuselage length, nacelle setting and rear fuselage shaping to reduce adverse pressure fields are illustrated. Typical pressure distributions and boundary layer traverses measured on the standard and super VC10 in flight are presented and comparisons are made with wind tunnel results. The data presented are evaluated for the probable mechanism of the complex interference forces set up by the presence of the power plants. Author

**N71-19376#** General Dynamics/Convair, San Diego, Calif.  
**EXPERIMENTAL RESULTS OF HIGH BYPASS RATIO**

## **TURBOFAN AND WING AERODYNAMIC INTERFERENCE**

J. E. Aldridge and J. L. Nye (GE) *In* AGARD Aerodyn. Interference Jan. 1971 12 p

Avail: NTIS HC\$6.00/MF\$0.95

Results of a wind-tunnel investigation into the interference effects of a pylon-wing-mounted, high-bypass-ratio turbofan on the aerodynamic characteristics of a twin engine subsonic airplane are presented. This was accomplished using a high-pressure, air turbine powered propulsion simulator mounted on a 1/7-scale semispan model of the airplane. Results show that significant interference does exist, and that it varies with free stream Mach number, engine power setting, and lift coefficient. Generally, the drag due to nacelle/body interference increases with Mach number, decreases as engine power is increased, and optimizes with lift coefficient. The interference level is either favorable or unfavorable depending on these parameters. The presence of the nacelle has no measurable effect on wing upper surface pressure distribution; however, wing lower surface, nacelle fan, and turbine cowl distributions are significantly altered. Author

**N71-19377#** Douglas Aircraft Co., Inc., Santa Monica, Calif.

# **DETERMINATION OF LOW SPEED INTERFERENCE EFFECTS BY SUPERPOSITION**

John L. Hess and Suzanne M. Faulkner *In* AGARD Aerodyn. Interference Jan. 1971 15 p refs

Avail: NTIS HC\$6.00/MF\$0.95

The application of a computer program for potential flow to problems of estimating aerodynamic interference is reported. Examples are presented of straightforward use of the program to calculate flow about more complicated configurations than could previously be handled. Superposition is also used to conserve computing time. The program greatly expands the usefulness of the superposition method. First, the component flows to be superposed may be any of the very general class of solutions that the program can calculate. Second, by comparing flows calculated by superposition with the same flows calculated exactly by the program, the limits of validity of the superposition principle can be determined with a new precision. Examples are presented of calculated flow fields and of comparisons of exact and superposed solutions. Author

**N71-19378#** Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

# **WIND TUNNEL INVESTIGATION INTO AERODYNAMIC INTERACTIONS INDUCED BY DROP LOADS [ETUDE EN SOUFFLERIE DES INTERACTIONS AERODYNAMIQUES DUES AUX CHARGES LARGABLES]**

J. Christophe and J. Coste *In* AGARD Aerodyn. Interference Jan. 1971 11 p refs *In* FRENCH; ENGLISH summary

Avail: NTIS HC\$6.00/MF\$0.95

Techniques for the investigation of aerodynamic interactions induced by drop loads are reviewed and some representative results are reported. Emphasis is placed on direct tracings of dropped load trajectories and microrocket propelled missiles by high speed filming in the wind tunnel. Obtained results are compared with those from the newly developed alternative method of weighing the load in the aerodynamic field of the aircraft and reconstructing its trajectory by computing routine. Author

**N71-19379#** Nielson Engineering and Research, Inc., Palo Alto, Calif.

# **A CALCULATIVE METHOD FOR PREDICTING STORE SEPARATION TRAJECTORIES AT SPEEDS UP TO THE CRITICAL SPEED**

Jack N. Nielson, Frederick K. Goodwin, and Marnix F. E. Dillenius *In* AGARD Aerodyn. Interference Jan. 1971 14 p refs  
Sponsored by AFFDL

Avail: NTIS HC\$6.00/MF\$0.95

A theory has been developed for predicting the trajectories of external stores dropped from high-speed aircraft up to the critical speed. The method consists of three steps: (1) prediction of the non-uniform flow field in the vicinity of the store; (2) prediction of store forces and moments in the nonuniform flow field; and (3) calculation of the trajectory. A vortex lattice method used for the first step predicts well the flow field velocity components under the wing or fuselage. A simplified slender body method for calculating the normal force and moment on the external store is moderately successful by comparison with experiment. Calculated trajectories based on the simplified method are in fair agreement with experiment.

Author

**N71-19380#** Aircraft Research Association, Ltd., Bedford (England).

#### EXAMPLES OF AIRFRAME STORE INTERFERENCE

J. B. Berry *In* AGARD Aerodyn. Interference Jan. 1971 12 p refs

Avail: NTIS HC\$6.00/MF\$0.95

Effects of airframe-store interference on the side force and the drag increment due to pylon mounted underwing stores are discussed. The main features of the sidewash and pressure distributions in the flow field beneath a swept wing are described. It is noted that, while the loads on a store would be expected to vary significantly with its position under the wing, some of the interference forces may be regarded as buoyancy effects, implying opposing forces on the aircraft. Examples of measured side force on stores and pylons show that a qualitative correlation can be obtained with underwing sidewash data. Comparisons of the axial force on stores and pylons and the drag increment with estimates of the freestream drag of the store assembly, are presented and, at low speed and low to moderate  $C$ , these demonstrate the expected cancellation of some of the interference forces. Brief descriptions of methods being developed for the prediction of store and pylon side force and installed drag increment are included.

Author

**N71-19381#** McDonnell Aircraft Corp., St. Louis, Mo.

#### EVALUATION OF THE PREDICTION OF AIRPLANE STORE INTERFERENCE BY LINEAR THEORY

Gordon G. Grose and Dean R. Bristow *In* AGARD Aerodyn. Interference Jan. 1971 12 p refs

Avail: NTIS HC\$6.00/MF\$0.95

A ring-body analysis computer program is used to calculate the interference flow field at a store location due to a wing-body combination, and the resulting loads applied to the store. Interference loads predicted by linear theory are compared with test data on typical fighter bomber configurations at subsonic and supersonic speeds. The subsonic case consists of stowed load wind tunnel data on a body representing the SUU-16A gun pod, mounted on the outboard wing pylon of the F-4C airplane. The supersonic case consists of loads on a sting supported store model in the vicinity of a swept wing-body combination representing a fighter bomber at Mach 1.6. The results of the comparison show the detailed survey of the interference flow field provided by the method, and indicate that it is a promising method of estimating store interference effects from the airplane geometry.

Author

**N71-19382#** Breguet-Aviation, Paris (France).

#### ANALYSIS OF THE EFFECTS OF EXTERNAL STORES FASTENED UNDER AN ARROW WING ON THE LONGITUDINAL STABILITY OF THAT AIRCRAFT [ANALYSE DE L'INFLUENCE DE CHARGES EXTERNES FIXEES SOUS LA VOILURE D'UN APPAREIL A AILE EN FLECHE SUR LA STABILITE LONGITUDINALE DE CET AVION]

R. Taisseire *In* AGARD Aerodyn. Interference Jan. 1971 13 p *In* FRENCH; ENGLISH summary

Avail: NTIS HC\$6.00/MF\$0.95

Wind tunnel test results show that external stores fastened under a swept wing by pylons decrease longitudinal stability of the aircraft. Most of this stability loss comes from the increased deflection of the horizontal tail due to vortice field development at the pylon's trailing edge; this is caused by the force of the local sideslip at the lower part of the wing that produce a lateral lift force on the pylon. The deflection changes the stability of the aircraft as a function of the angle of attack.

Author

**N71-19383#** Boeing Co., Wichita, Kans.

#### SEPARATION CRITERIA FOR DENSELY PACKED STORES IN BOMB BAYS

Richard B. Holloway, Donald L. Sutcliffe, and James D. Woodward *In* AGARD Aerodyn. Interference Jan. 1971 10 p

Avail: NTIS HC\$6.00/MF\$0.95

Separation characteristics of the weapons in the densely packed B-52 bombing system configuration 1224-7 proved to be dependent on the release sequence, release interval and release airspeed. Several different release sequences were investigated to solve bomb collision problems. A successful sequence was derived which provided satisfactory bomb release characteristics when a minimum clearance of one bomb diameter between adjacent bombs is provided as the bomb clears the guide rails. Flight tests indicated the optimal performance of a three-bay configuration with a minimum release interval of 80 to 50 milliseconds.

Author

**N71-19384#** Royal Aircraft Establishment, Farnborough (England).

#### FLIGHT INVESTIGATION OF A TECHNIQUE FOR THE MEASUREMENT OF THE TOTAL AND INTERFERENCE DRAG OF EXTERNAL STORES

K. P. King *In* AGARD Aerodyn. Interference Jan. 1971 13 p refs

Avail: NTIS HC\$6.00/MF\$0.95

Results are given of the flight investigation of a technique for the measurement of the drag of external stores which can be jettisoned. The technique is to drop the stores and evaluate the store drag from the resultant change in aircraft acceleration along the flight path. In an exploratory series of tests, 1000 lb bombs were dropped from a Hunter aircraft and the variation of the drag due to the stores as they separated from the aircraft was determined. The results indicate that, with this particular aircraft/store combination, there is no significant variation of the total installed drag with  $C_{sub L}$  over the range tested but the interference drag varies linearly with  $C_{sub L}$  squared.

Author

**N71-19385#** General Dynamics/Pomona, Calif.

#### A METHOD FOR PREDICTING INTERFERENCE FORCES AND MOMENTS ON AIRCRAFT STORES AT SUBSONIC SPEEDS

F. D. Fernandes *In* AGARD Aerodyn. Interference Jan. 1971 9 p refs

Avail: NTIS HC\$6.00/MF\$0.95

A method is developed for theoretically predicting the loading on aircraft stores at separation for subsonic flow. The method consists of predicting the flow field about the aircraft by using singularity distributions to represent the aircraft according to linear theory; the effect of the variable interference flow field is integrated over the store by using the free-air load distribution properties of the store locally. Buoyancy effects are included. The loading over each store fin is given special consideration with regard to its interaction with the aircraft pylon and with other store surfaces. A FORTRAN computer program performs the calculations. Effects of aircraft wing, fuselage, pylons, and inlets are included. Store moment calculations under an F-4C aircraft are compared with test data.

Author

**N71-19386#** Naval Ship Research and Development Center, Washington, D.C.

**A STUDY OF CAPTIVE FLIGHT DRAG AND SEPARATION CHARACTERISTICS OF LIFTING BODY (HALF BOMB AND HALF POD) STORE CONFIGURATIONS**

Roger J. Furey and C. Joseph Martin *In* AGARD Aerodyn. Interference Jan. 1971 11 p refs

Avail: NTIS HC\$6.00/MF\$0.95

The use of lifting bodies as a basic shape for externally carried stores is considered as a means of overcoming the large incremental drag and poor separation qualities of the more conventionally shaped aircraft stores. Wind-tunnel tests were conducted on a half-bomb and a half-pod to determine their captive flight drag and separation characteristics. Testing was conducted at Mach numbers of 0.74 and 1.88. The half-bombs were found to have as much as a 35 percent drag reduction, in a simulated captive flight condition, over its equivalent whole-bomb counterpart, and separated cleanly without the use of an ejection force under all conditions tested. The half-pod configuration produced as much as a 20 percent drag reduction over that of the equivalent whole-pod. It also separated cleanly although an ejection force was necessary in order to prevent a pitch-up maneuver and possible collision at the higher Mach number. Author

**N71-19387#** Naval Ordnance Lab., White Oak, Md.

**AIRCRAFT/STORE INTERFERENCE**

Chris A. Kalivretenos *In* AGARD Aerodyn. Interference Jan. 1971 16 p refs

Avail: NTIS HC\$6.00/MF\$0.95

A series of tests relating to the carriage and separation characteristics of a newly developed rocket launcher pod are reported. The objectives of the tests were to identify those flight conditions under which separation of the launcher might result in damage to the aircraft and to obtain data from which the separation behavior could be predicted. Included in this series of tests was a pod installation force test, a flow-field survey test and a pod jettison test. In each investigation, the loaded and empty rocket launcher pods were suspended from the centerline and outboard shoulder stations of the scaled triple ejector rack located on the inboard wing station of an A-4 aircraft model. The pod tends to pitch nose upward at high aircraft angles of attack and nose downward at low aircraft angles of attack. In full-scale tests the nose of the empty pod collides with the wing of the aircraft when launched from the shoulder station at airspeeds below 250 knots and the tail impacts the rack when launched from the centerline at airspeeds above 450 knots. Author

**N71-19388#** Naval Ship Research and Development Center, Washington, D.C.

**PREDICTION OF STORE LAUNCH CHARACTERISTICS THROUGH STATISTICAL METHODS**

Michael A. Sekellick *In* AGARD Aerodyn. Interference Jan. 1971 11 p refs

Avail: NTIS HC\$6.00/MF\$0.95

Two statistical methods are presented which have the capability of generating equations to predict the separation characteristics of airborne stores from aircraft. A mathematical relation was found between a configuration, the launch conditions, and the associated trajectory. The aircraft/store combination was described by parameters representing the important geometric and physical features which affect separation behavior. Each launch event was catalogued in terms of such parameters and the resulting separation behavior. This data was then statistically analyzed to predict the outcomes of untried launch situations. Author

**N71-19391#** Aeronautical Research Labs., Melbourne (Australia). **THE EFFECT OF RELAXATION IN SCALING PARAMETERS ON THE FREE FLIGHT PATH OF A WIND TUNNEL MODEL WITH FORCED EJECTION**

D. A. Lemaire and P. T. Malone Jun. 1970 24 p ref (ARL/A-322) Avail: NTIS

For the case of a nose strake ejected upstream of a body, the effect of certain relaxation of the basic similarity criteria on the subsequent flight path of a scale model in a wind tunnel is considered. A scaling approximation based on (velocity) squared is derived and wind tunnel experiments to determine its validity are described. Comparative trajectories are also given for a specific model over a range of wind speeds, and it appears that considerable variation in test wind speed may be permissible if the full-scale density ratio is preserved. Author

**N71-19397#** National Academy of Sciences-National Research Council, Washington, D.C.

**VISUAL FACTORS IN TRANSPORTATION SYSTEMS**

1969 135 p refs Presented at the Proc. of Spring Meeting, NAS-NRC Comm. on Vision, 1969 (PB-196014) Avail: NTIS CSCL 13F

Contents: Visual problems of truck and bus drivers; Visual problems in automobile driving; Factors in visibility and legibility of highway signs and markings; Requirements for automobile exterior lighting; Factors in highway lighting; Selected visual problems of an airline pilot; Visual problems of the air traffic controller; Some display concepts in air traffic control; The helicopter in high density traffic; Measurement of height and distance information provided pilots by the extra-cockpit visual scene; Visual illusions in aircraft accidents. GRA

**N71-19401#** National Research Council of Canada, Ottawa (Ontario).

**DIVISION OF MECHANICAL ENGINEERING AND THE NATIONAL AERONAUTICAL ESTABLISHMENT Quarterly Bulletin, 1 Jul. - 30 Sep. 1970**

30 Sep. 1970 75 p refs

(DME/NAE-1970(3)) Avail: NTIS

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2. NAE MULTI-SOURCE SCHLIEREN APPARATUS FOR 5-FOOT  $\times$  5-FOOT TRISONIC WIND TUNNEL A. Bowker p 27 - 49 refs

**N71-19403#** National Aeronautical Establishment, Ottawa (Ontario). High Speed Aerodynamics Lab.

**NAE MULTI-SOURCE SCHLIEREN APPARATUS FOR 5-FOOT  $\times$  5-FOOT TRISONIC WIND TUNNEL**

A. Bowker *In* Natl. Res. Council of Canada Div. of Mech. Eng. and The Natl. Aeron. Estab. 30 Sep. 1970 p 27 - 49 refs

Avail: NTIS

The in-house development of a multiple-source schlieren system for the National Aeronautical Establishment Trisonic wind tunnel is described. The basic optical elements and their mechanical arrangements are shown in schematics. The control panels, and operational procedures are also described. F.O.S.

**N71-19426#** Gage-Babcock and Associates, Inc., Westchester, Ill.

**MINIMUM NEEDS FOR AIRPORT FIRE FIGHTING AND RESCUE SERVICES Final Report**

Bert M. Cohn and John A. Campbell Jan. 1971 95 p refs  
(Contract DOT-FA71WA-2487)

(FAA-AS-71-1; Rept-7113) Avail: NTIS

In order to develop minimum standards for airport fire fighting and rescue services complying with the intent of the Airport and Airway Development Act of 1970, a study was made of the needs for different categories of airports serving air carriers certificated by the Civil Aeronautics Board. The study consisted of a review of the state-of-the-art, analysis of accident reports, extrapolation of data from various sources, and discussions concerning these services with various owner and user oriented organizations. Recommendations are presented for adoption as the minimum requirements covering quantities and application rates for fire extinguishing agents, the number of vehicles to transport the agents, vehicle response times, manning, and other related elements which comprise these services. Author

**N71-19434#** Gibbs and Hill, Inc., New York.

**AIRPORT ACCESS STUDY: FRIENDSHIP INTERNATIONAL AIRPORT**

Sep. 1970 210 p Sponsored in part by Federal Railroad Admin.  
(PB-196023) Avail: NTIS CSCL 13F

The study indicates that the most attractive method of providing rail access to Friendship International Airport from the metropolitan centers of Washington, D.C. and Baltimore, Md. would be through the implementation of a high-speed electric service running directly to a new railroad terminal at the Airport from Union Station in Washington and Camden Station in Baltimore. Use would be made of existing Penn Central and Baltimore and Ohio Railroad routes and facilities, with a connection between the two at Winans and an additional track on the Penn Central. Author (GRA)

**N71-19449\*** Melpar, Inc., Falls Church, Va.

**TELEVISION SIMULATION FOR AIRCRAFT AND SPACE FLIGHT Patent**

John E. Conant, inventor (to NASA) Issued 29 Jul. 1969 (Filed 10 Nov. 1965) 9 p Cl. 178-6; Int. Cl. H04n7/00, 3/16, 5/38 Sponsored by NASA

(NASA-Case-XFR-03107; US-Patent-3,458,651;

US-Patent-Appl-SN-507257) Avail: US Patent Office CSCL 17B

A wide angle image transmission and projection system, in which a single camera is used in cooperation with a single projection unit to provide a wide angle image on a projection screen is described. The latter is fixedly positioned with respect to the projection unit which includes optics to control the relative position of the projected image on the fixed screen so as to simulate roll, pitch, and azimuth angle of the projected image with respect to a fixed optical axis. The center of the projection surface is aligned to the optical axis. Official Gazette of the U.S. Patent Office

**N71-19451\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**AIRCRAFT PROPULSION**

Washington 1971 463 p refs Conf. held at Cleveland, 18 - 19 Nov. 1970

(NASA-SP-259) Avail: NTIS HC\$6.00/MF\$0.95 CSCL 21A

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**N71-19452\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FAN AND COMPRESSOR TECHNOLOGY**

Melvin J. Hartmann, William A. Benser, Cavour H. Hauser, and Robert S. Ruggeri *In its Aircraft Propulsion* 1971 p 1-36 refs

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 21E

Fans and compressors for advanced engines are described. The compressor of a turbojet engine requires a number of high pressure ratio stages. A low bypass ratio turbofan engine may require two or three stages in the fan. For high bypass ratio engines, the fan pressure ratio is low and single-stage fans may be adequate. Some of the general requirements of fans and compressors are listed. As usual, high component efficiency is essential for low specific fuel consumption. Light weight is generally desirable for all applications. Light weight may be achieved by using high pressure stages so that fewer stages are required to achieve the required pressure. Light weight materials and advanced construction techniques must also be used. Fans and compressors must operate over a wide range of flows and must tolerate inlet flow distortions that may occur during some portions of the flight. Low noise limits may require the selection of specific rotational speeds and blade loadings. Even with suitable selection of these parameters, considerable noise suppression may be required. Author

**N71-19453\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**TURBINE AERODYNAMIC CONSIDERATIONS FOR ADVANCED TURBINES**

Thomas A. Moffitt, Stanley M. Nosek, and Richard J. Roelke *In*

## N71-19454

*its Aircraft Propulsion* 1971 p 37-55 refs

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 21E

Advanced engines offer many interesting challenges to the turbine designer. For example, the continuing trend to higher temperature complicates the problem of effectively cooling the turbine. Another example is the trend in fan engines toward higher bypass ratios. These trends create special problems for the turbines that drive these fans. Some of the turbine aerodynamic work to study two of these problem areas is presented. Author

**N71-19454\***# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### **TURBINE COOLING RESEARCH**

Herman H. Ellerbrock and Reeves P. Cochran *In its Aircraft Propulsion* 1971 p 57-96 refs

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 21E

Turbine cooling for application to aircraft gas turbine engines at gas temperatures up to about 4000 F and gas pressures up to about 600 psia is discussed. Present facilities permit experimental research at gas temperature and pressure of about 2500 F and 125 psia, respectively. The purposes of this paper are threefold, namely, (1) to discuss the objectives of the turbine cooling program, (2) to indicate how and with what facilities the research is conducted, and (3) to present some results that have been obtained. Author

**N71-19455\***# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### **COMBUSTION**

Jack Grobman, Robert E. Jones, Cecil J. Marek, and Richard W. Niedzwiecki *In its Aircraft Propulsion* 1971 p 97-134 refs

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 21E

The latest engine operating conditions affecting the problems in combustor design are reviewed. The research approaches being used to solve these problems are discussed. By way of review, the various criteria that are used in the design of gas turbine combustors are considered. Author

**N71-19456\***# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### **V/STOL PROPULSION**

Newell D. Sanders, James H. Diedrich, James L. Hassell, Jr., David H. Hickey, Roger W. Luidens et al *In its Aircraft Propulsion* 1971 p 135-168

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 21E

The propulsion technology for commercial airplanes designed for short takeoff and landing (STOL) or for vertical takeoff and landing (VTOL) is described. Some differences between these airplanes and conventional takeoff and landing (CTOL) airplanes are illustrated by the trajectories. A greater demand for engine thrust, or lift, exists from CTOL to STOL and to VTOL airplanes. Values of engine thrust to airplane gross weight might be as follows: (1) CTOL airplanes, 0.3, (2) STOL airplanes, 0.6, and (3) VTOL airplanes, 1.2. The desired thrust of the STOL airplane is double the thrust of the CTOL airplane. The VTOL airplane requires another doubling of the thrust. These values are generalizations; they are intended to convey a sense of magnitude only. Author

**N71-19457\***# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

## **NOISE REDUCTION**

James J. Kramer, David Chestnutt, Eugene A. Krejsa, James G. Lucas, and Edward J. Rice *In its Aircraft Propulsion* 1971 p 169-210

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 01B

Both conventional takeoff and landing (CTOL) and vertical/short takeoff and landing (V/STOL) aircraft noise is discussed. The subsonic aircraft flight profile is considered first. Noise is a factor for subsonic aircraft when they are landing and taking off. These aircraft land on a 3 deg glide slope, so that their altitude above the community is fairly well defined as a function of distance from touchdown. The engine power setting varies as the pilot maneuvers down the glide slope, but generally the engines are at about 25 percent of takeoff thrust. During takeoff the altitude above the community depends on the operating weight of the aircraft and the power setting. It is possible for the pilot to reduce power after he has achieved some safe altitude. This power reduction results in less noise. Author

**N71-19458\***# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### **LOW COST ENGINES FOR AIRCRAFT**

Robert L. Cummings and Harold Gold *In its Aircraft Propulsion* 1971 p 211-231

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 21A

The very high cost of current gas turbine engines which substantially restricts their use is discussed. The approximate cost of several current general aviation engines are shown. The general aviation light plane must be suitable for a retail sales price of around \$30,000 for a single-engine aircraft and \$45,000 for a light twin-engine aircraft. For the high flight speeds, a 425-horsepower engine would be required, but the price of over \$17,000 is already too high. The currently available turbojet, turboshaft, and fanjet engines are much too costly, with prices ranging from \$22,000 to over \$65,000. The competitive impact of a really low-cost gas turbine engine with a 1000-pound static sea level thrust having a total manufacturing price of \$5000, or \$5 per pound of thrust is described. Such an engine would provide important performance gains for light aircraft and also have a very important price advantage over either current piston engines or current jet engines. In order to sell at 1/5 the price per pound of thrust of current jet engines, however, this engine would require really major design simplifications and manufacturing cost reduction. Author

**N71-19459\***# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### **SUPERSONIC EXHAUST NOZZLES**

Milton A. Beheim, Bernhard H. Anderson, John S. Clark, Blake W. Corson, Jr., Leonard E. Stitt et al *In its Aircraft Propulsion* 1971 p 233-282 refs

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 21A

A major problem in the design of an exhaust system for a supersonic airplane is that its geometrical shape should change as flight conditions are changed. The sonic area and expansion ratio must be variable, and it might also be required to reverse thrust and to suppress jet noise or infrared radiation. The mechanisms that are needed to do this can be complicated and heavy. Therefore, there is a trade between weight and performance that depends on the mission. The missions for supersonic aircraft can be divided into the following types: (1) Supersonic cruise, such as the B-70, SR-71, and the supersonic transport and (2) Supersonic dash, such as the B-58, F-4, F-111, B-1, F-14, and F-15. The supersonic dash aircraft fly long distances subsonically but are also able to go supersonic for relatively short distances. Exhaust nozzle concepts for both types of aircraft are considered in this section. Supersonic

cruise nozzle are discussed first, and then some of the supersonic dash problems are described. Author

**N71-19460\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### **SUPERSONIC CRUISE INLETS**

David N. Bowditch, Robert E. Coltrin, Bobby W. Sanders, Norman E. Sorensen, and Joseph F. Wasserbauer *In its Aircraft Propulsion* 1971 p 283-312 refs

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 21A

For supersonic cruise at Mach numbers greater than 2, one of the inlet parameters that affects these important inlet characteristics is the internal contraction of the supersonic diffuser. The performance of several inlets to show how the amount of internal contraction affects their characteristics is discussed. Not only those inlet characteristics that can be measured in terms of range are considered, but also inlet characteristics such as angle-of-attack tolerance which are more difficult to evaluate. In addition, methods to improve the stability of the internal contraction inlets and some typical distortions that have been measured during wind tunnel testing are described. Author

**N71-19461\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### **EFFECTS OF ENGINE INLET DISTURBANCES ON ENGINE STALL PERFORMANCE**

John H. Povolny, F. W. Burcham, Jr., James E. Calogeras, Carl L. Meyer, and Richard A. Rudey *In its Aircraft Propulsion* 1971 p 313-341 refs

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 21A

The operating limits of propulsion systems may restrict the capabilities of both subsonic and supersonic aircraft. One such limit of gas turbine propulsion systems is compressor stall or surge. The performance and operating limits of the engine, especially the compressor system, are influenced by the flow conditions at the engine inlet. This leads to the necessity of adequately matching the inlet and engine so that the capabilities of the aircraft are not compromised by the condition of the flow supplied by the inlet to the engine or the susceptibility of the engine compressor system to this flow. It should be noted that, in addition to the inlet design parameters, the condition of the flow is also determined by external influences such as armament firing, flight maneuvers, thrust reversal, inlet unstart, inlet buzz, some of which cause temperature as well as pressure disturbances. In order to better understand the flight environmental disturbances and their effects on the operating limits of turbine engines, research programs are being conducted. Data obtained from these programs are presented. Author

**N71-19462\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### **DYNAMICS AND CONTROL**

Aaron S. Boksenbom, Gary L. Cole, Daniel I. Drain, Kirby W. Hiller, Ross G. Willoh et al *In its Aircraft Propulsion* 1971 p 351-395 refs

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 21E

Major problems in dynamics and controls of a supersonic propulsion system are presented. The job of the control (inlet control, engine control, and coupling signals between the inlet and the engine) is to avoid severe, damaging, or unstable conditions throughout the system. They also maintain system operation at the desired or optimum condition and, when required, move the system from one operating point to another. To design such controls requires an understanding of the dynamic, as well as the static, performance of all system components. Author

**N71-19463\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### **CRYOGENIC FUELS FOR AIRCRAFT**

Jack B. Esgar *In its Aircraft Propulsion* 1971 p 397-420 refs

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 21D

Exploratory research on the use of cryogenic fuels for airbreathing gas turbine engines is presented. The two prime reasons for the interest in cryogenic fuels for advanced aircraft are the higher heating value per pound of fuel and the heat sink capacity that is available in this fuel for cooling hot components in the engine or the aircraft. The possible applications of liquid methane to a supersonic transport type aircraft and the application of liquid hydrogen to the airbreathing engines for recoverable boosters and orbiters for the space shuttle are discussed. Author

**N71-19464\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

#### **ADVANCEMENTS IN BEARINGS, SEALS, AND LUBRICANTS**

Erwin V. Zaretsky and Lawrence P. Ludwig *In its Aircraft Propulsion* 1971 p 421-463 refs

Avail: NTIS HC\$6.00/MF\$0.95 CSCL 11A

Advances in airbreathing turbojet engines have dictated that bearing materials and lubricants operate at higher temperatures, higher speeds, and higher loads. The first generation supersonic transport (SST) turbine engine main-shaft bearings will operate at a bearing temperature of 425 deg F and a maximum speed of 1.3 million DN. It is anticipated that more advanced engine designs may require bearings to operate at temperatures between 500 and 550 F and speeds of approximately 2 million DN. Projection of these trends would predict bearing temperatures to 600 F and bearing speeds of 3 to 4 million DN, which would produce higher bearing operating stresses. A summary of the rolling-element bearing and seal state of the art contributions to solving problems encountered in advanced airbreathing turbojet engines is presented. Author

**N71-19488#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

#### **POWER PLANTS FOR AIRCRAFT WITH AIR-BREATHING ENGINES**

V. I. Polikovskii and D. N. Surnov 22 Oct. 1970 351 p refs Transl. into ENGLISH of the book "Silovye Ustanovki Letatelnykh Apparatoe Svobodushno-Reaktivnymi Dvigatelyami" 1965 p 1-261

(AD-716496; FTD-HC-23-595-69) Avail: NTIS CSCL 21/5

The textbook supplies the necessary information for planning the basic systems of a modern aircraft power plant with an air-breathing jet engine. The aspects of engine operation in an aircraft are compared with the conditions of its operation on a stand, and the general requirements that apply to the power plant and its systems are derived. Separate chapters are devoted to the fuel systems, air intake and exhaust systems, and systems for scavenging and engine cooling. Author (GRA)

**N71-19496** Tennessee Univ., Knoxville.

#### **ON SOME ASPECTS OF SHOCK WAVE OSCILLATIONS IN SUPERSONIC DIFFUSERS**

Dieter Jacob (Ph.D. Thesis) 1969 159 p

Avail: Univ. Microfilms: HC \$7.40/Microfilm \$3.00 Order No. 70-2115

Literature pertinent to the oscillating interaction of shock waves and turbulent boundary layers is critically reviewed. The

## A71-19515

unsteady interaction of harmonic upstream or downstream disturbances with normal shock waves in nonviscous, quasi-one-dimensional diffuser flow is treated. A numerical method is presented which applies to arbitrary diffuser shapes. Solutions for different exit conditions and upstream disturbances are discussed. Dissert. Abstr.

**N71-19516#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**CONSTRUCTION AND OPERATION OF THE AN-24 AIRPLANE [SAMOLET AN-24 KONSTRUKTSIYA I EKSPULATSIYA]**

Zh. S. Chernenko et al 26 Oct. 1970 576 p refs Transl. into ENGLISH from the Russian  
(AD-716499; FTD-HC-23-448-69) Avail: NTIS HC \$6.00/MF \$0.95 CSCL 1/3

The book presents the basic data on the AN-24 airplane, including descriptions of the airframe, flight controls, landing gear, power plant, hydraulic, fuel, fire protection, anti-icing, air conditioning systems, and ground equipment. Each chapter includes some recommendations on servicing the individual components, assemblies, and systems. A separate chapter covers airplane operations. Author (GRA)

**N71-19548#** Ballistic Research Labs., Aberdeen Proving Ground, Md.

**AN EXPERIMENTAL INVESTIGATION OF THE SUPERSONIC TURBULENT BOUNDARY LAYER IN A MODERATE ADVERSE PRESSURE GRADIENT. PART 1: A DETAILED DESCRIPTION OF THE EXPERIMENT AND TABULATION**

Walter B. Sturek Oct. 1970 131 p refs  
(AD-716336; BRL-1506-Pt-1) Avail: NTIS CSCL 20/4

Experimental measurements of the profile characteristics of the supersonic turbulent boundary layer in a region of zero pressure gradient and in a region of moderate adverse pressure gradient along the curved surface of an isentropic ramp model are reported. Detailed surveys of impact pressure, static pressure and total temperature were taken through the boundary layer and local values of wall shear stress were obtained using the Preston tube technique. The measurements were made in a supersonic wind tunnel for a nominal tunnel nozzle setting of Mach 3.5. The data are for an adiabatic wall with values of momentum thickness Reynolds number ranging from 19,000 to 42,000. The experiment is described in detail and the mean profile data are presented in tabular form. Fluctuation data obtained using constant temperature hot wire anemometry are presented for one station in the region of zero pressure gradient and for one station in the region of adverse pressure gradient. Author (GRA)

**N71-19549#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Flight Dynamics Lab.  
**THE ACOUSTIC ENVIRONMENT OF A DEFLECTED-JET VTOL AIRCRAFT**

D. L. Smith and S. L. McFarland, Jr. Sep. 1970 44 p refs  
(AD-715939; AFFDL-TM-70-1-FYA) Avail: NTIS CSCL 20/1

A noise survey conducted on a deflected-jet VTOL aircraft is described. The test aircraft was mounted on a vertical thrust stand with the nozzles oriented in the hover-stop position while engine runs were made at different power settings. Forty-one (41) microphones were located in the field on the port side of the aircraft and six (6) microphones were located at positions near the aircraft skin. The height of the field microphones was varied (5 ft, 10 ft, and 15 ft). One-third octave band spectra obtained from all microphones and for all engine power settings were flat and did not exhibit the haystack shape which is characteristic of a free jet. Typical one-third octave band sound pressure level spectra and contours of overall sound pressure level are presented. Estimates of

jet total acoustic power are developed from the measurements and related to engine operating parameters. Expressions are derived to predict the one-third octave band spectra at positions in the field and on the vehicle from similarly configured aircraft for various engine operating conditions. Author (GRA)

**N71-19558#** Solar, San Diego, Calif.  
**ROTATING VANELESS DIFFUSER STUDY Final Report, Oct. 1969 - Sep. 1970**

C. Rodgers and H. Mnew Ft. Belvoir, Va. Army Mobility Equipment Res. and Develop. Center Oct. 1970 82 p  
(Contract DAAK02-70-C-0148)  
(AD-716370; ER-2249) Avail: NTIS CSCL 20/4

An analytical and experimental investigation of the free vaneless rotating diffuser concept demonstrated both mechanical feasibility and aerodynamic effectiveness. The objectives of the program were to design, manufacture, and test a model rotating vaneless diffuser in a simulated compressor environment, to measure the performance gains, and to establish and verify an analytical design and performance method. The conclusions of the program are: (1) The free rotating vaneless space diffuser is mechanically feasible; (2) The free rotating vaneless space diffuser reduces diffusion losses by an amount depending on compressor pressure ratio and specific speed; (3) The analytical predictions of loss reduction were verified; (4) The exit traverse test results support the argument that the rotating diffuser will tend to smooth out distorted inlet flow profiles. Author (GRA)

**N71-19559#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.  
**THE EFFECT OF ELASTICITY ON THE LIFTING FORCE OF A WING**

B. S. Berkouskiy 30 Oct. 1970 10 p refs Transl. into ENGLISH from Dopovidi Akad. Nauk Uk. SSR (Kiev), No. 11, 1967 p 1044 1048  
(AD-716509; FTD-HC-23-1193-68) Avail: NTIS CSCL 1/1

A deformable bearing surface is of interest from the standpoint of designing rigid structures and obtaining controllable aerohydrodynamic characteristics. In the article static aerohydroelasticity is investigated. A general equation is considered for the deformation of the bearing surface in an ideal noncompressible infinite stream. The elastically deformed load-bearing surface is investigated by assuming that the theory for the large aspect ratio airfoil is applicable. An integral-differential equation is obtained for an elastic airfoil. The solution of this equation gives a dependence for the lift coefficient of a nondeformable airfoil and the function for the effect of elasticity. Author (GRA)

**N71-19560#** Fort Detrick, Frederick, Md. Munitions Development Div.

**ON FLIGHT DYNAMICS OF MAGNUS ROTORS**

Peter H. Zipfel (Ph.D. Thesis) Nov. 1970 285 p refs  
(AD-716345; SMUFD-TR-117; AMXFD-AE-T-50403) Avail: NTIS CSCL 20/4

A Magnus rotor is an autorotating flight vehicle, designed to develop a Magnus force efficiently and to employ it as the major lift force in free flight. The equations of motion of Magnus rotors are derived and their performance and stability analyzed and correlated with free flight tests. Necessary and sufficient conditions for limit cycles are derived, and it is shown how limit cycles can be avoided by proper design of the Magnus rotor. Thirty models were flight tested. Their trajectories and attitude motions are correlated with computer simulations whose aerodynamic input data are solely based on wind tunnel tests. The agreement is satisfactory. Two different Magnus shapes were tested for limit cycles. The test results agree well with predictions. Author (GRA)

**N71-19574#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**PLASTIC WING WITH LAMINAR PROFILE**

O. R. Cheranovskii et al 26 Aug. 1970 13 p refs Transl. into ENGLISH from Samoletost. Tekh. Vozdush. Flota (USSR), no. 16, 1968 p 101-106

(AD-716526; FTD-HT-23-400-70) Avail: NTIS CSCL 1/3

A brief review is presented of the design and fabrication problems of plane and trapezoidal fiberglass wings with laminar profiles to be used in aerodynamic tests on an automatic airborne laboratory under real flight conditions. Techniques for manufacturing such plastic wings with required specifications and surface roughness and configuration allowances are described. The properties and fabrication of the wing rigging are discussed, and a version of a slotted plastic wing producing laminarization is described. A lower production cost, a simpler manufacturing technology, and higher aerodynamic properties are noted as the advantages of these plastic wings over riveted or wooden wings. Author (GRA)

**N71-19603#** Pennsylvania State Univ., University Park.

**TURBULENCE CHARACTERISTICS OVER HETEROGENEOUS TERRAIN Final Report**

Hans A. Panofsky, Carl A. Mazzola, James Woods, and Karl Eidsvik Sep. 1970 89 p refs

(Contract DAEA18-69-C-0079)

(AD-716361; ECOM-0079-F) Avail: NTIS CSCL 4/1

The report summarizes some results from three separate field studies, in the United States and Norway. These conclusions are reached: The Bradshaw-Peterson hypothesis that the ratio of the standard deviation of velocity components to the friction velocity is a universal function of Richardson number even when the air is not in equilibrium appears to be correct in the case of the standard deviation of vertical velocity. In that case, the ratio is approximately 1.3 in neutral air. For the horizontal velocity components, the hypothesis is only approximately true; these components have low-frequency, mesoscale contributions which obey neither Monin-Obukhov similarity nor the above-named hypothesis. The hypothesis that the ratio between dissipation and friction velocity cube over height also has a general value in neutral air appears to be correct. The value is about the reciprocal of von Karmans constant. Spectra of vertical motion, multiplied by wave number and normalized by the variance or the square of friction velocity, have universal shapes, depending only on Richardson number in stable air. Author (GRA)

**N71-19611#** Rhode Island Statewide Comprehensive Transportation and Land Use Planning Program, Providence.

**STATE AIRPORT SYSTEM AIRLINE PASSENGER TICKET SURVEY**

Sep. 1970 41 p Sponsored in part by HEW and DOT /ts Tech. Paper No. 17

(PB-195939) Avail: NTIS CSCL 01E

In the course of collecting data for a report on state airport system plan criteria and forecasts, 1970-1990, a survey was conducted involving all the airlines at Theodore F. Green State Airport to determine the number of passengers carried and their destinations. It was decided to compile the data received into a separate technical paper for use in preparing projections of future air transportation demands and in determining the requirements for the state airport system for the next 20 years. Author (GRA)

**N71-19630#** Bolt, Beranek, and Newman, Inc., Cambridge, Mass.

**ACOUSTICAL EVALUATION OF THE NASA LANGLEY FULL-SCALE WIND TUNNEL**

Istvan L. Ver, Charles I. Malme, and Eugene B. Meyer 15 Jan.

1971 35 p refs

(Contract NAS1-9559)

(NASA-CR-111868; Rept-2100) Avail: NTIS CSCL 14B

The acoustical measurements done at the NASA Langley Research Center's Full Scale Wind Tunnel are summarized. The purpose of these measurements was to supply NASA Langley operating personnel with data indicating the types of acoustical measurements which can be undertaken in the tunnel test section. The series of measurements included: (1) evaluation of the octave band ambient noise level in the test section with the tunnel fans stationary; (2) evaluation of the octave band noise levels in the test section as a function of the air speed in three different locations in the tunnel test section; (3) mapping of the sound field of an omnidirectional continuous broadband sound source of known power output; and (4) measurement of decay rate in the test section and in certain other locations in the tunnel. An analysis of the measured data indicates that the test section of the full scale wind tunnel has potential as an environment for performing some types of acoustical measurements. The validity of the test results is dependent upon the type of noise source to be investigated (on the acoustical power output, radiation pattern frequency spectrum and dimensions of the source), the distance from the source where measurements are to be taken, and upon the air flow conditions. Author

**N71-19635#** National Research Council of Canada, Ottawa (Ontario). Div. of Mechanical Engineering.

**BALANCE MEASURED THRUST PERFORMANCE OF VARIOUS COWLED AXIAL FAN CONFIGURATIONS IN A MAINSTREAM AT 90 DEG INCIDENCE**

R. A. Tyler and R. G. Williamson Oct. 1970 155 p refs

(NRC-11740; LR-543) Avail: NTIS

Balance measured force data are presented for a series of thrusting fan configurations (tip dia 15 in) operated in crossflow, at 90 deg incidence, in the 10 ft. x 20 ft NRC V/STOL Propulsion Tunnel. Test conditions involved tunnel speeds from 30 to 130 ft/sec in combination with mean intake velocities from 100 to 400 ft/sec. The force data provide a direct measure of fan gross thrust performance at constant fan speed, under conditions of increasing forward speed, i.e. increasing inflow distortion. Limited pressure data afford an indication of the behavior of overall fan pressure ratio under the same conditions. A total of 51 different configurations was tested, providing some insight into the effects of various configurational variables on thrust performance sensitivity to cross-flow conditions. Author

**N71-19656#** Naval Ordnance Lab., White Oak, Md.

**FLOW VISUALIZATION STUDIES OF A FIN PROTRUBERANCE PARTIALLY IMMERSSED IN A TURBULENT BOUNDARY LAYER AT MACH 5**

Allen E. Winkelmann 20 May 1970 56 p refs

(AD-716023; NOLTR-70-93) Avail: NTIS CSCL 20/4

Various flow visualization results are presented for a cylindrically blunted, unswept fin (yawed and unyawed) partially immersed in a turbulent boundary layer (sigma approximates 2.6 inches). The model, consisting of a fin-flat plate combination, was mounted on the test plate nozzle wall of a boundary layer channel. Experiments were completed at a nominal Mach number of 5 and nominal free stream Reynolds numbers per foot of  $2.8 \times 10$  to the 6th power and  $7.4 \times 10$  to the 6th power. Azobenzene tests show regions of high heat transfer to occur on the flat plate immediately upstream and downstream of the fin. Oil smear tests show in detail the surface shear directions and locations of separated flow which occur on the model. Schlieren and shadowgraph photographs indicate the complex shock wave structure which exists in front of the fin. A possible flow field model is suggested to account for the observed flow patterns. Author

**N71-19677#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**A STATUS REVIEW OF LEWIS RESEARCH CENTER SUPPORTED PROTECTION SYSTEM DEVELOPMENT**

S. J. Grisaffe, J. P. Merutka, and S. R. Levine [1971] 13 p refs Presented at 18th Refractory Composite Working Group, Huntsville, Ala., 16-18 Mar. 1971; sponsored by NASA and US Air Force (NASA-TM-X-52977) Avail: NTIS CSCL 11C

The status of several Lewis Research Center sponsored coating research and development studies is reviewed. Efforts on protecting superalloy and dispersion strengthened materials for aircraft gas turbine engines and on protecting refractory metals for reentry systems are discussed. Author

**N71-19696#** Air Force Systems Command, Wright-Patterson AFB, Ohio, Foreign Technology Div.

**OPTIMAL CONTROL OF ELASTIC FLIGHT VEHICLES**

A. A. Baloev 9 Oct. 1970 12 p refs Transl. into ENGLISH from Tr. Kazansk. Aviat. Inst. (Kazan), no. 103, 1968 p 54-60 (AD-716517; FTD-HT-23-454-70) Avail: NTIS CSCL 1/3

A study was made of the optimal control of the rotational and transversal motions of flight vehicles taking into account their torsional and flexural deformations. The equations for the torsional vibrations of the vehicle at high Mach numbers are analyzed. The optimal control of bending deformations is approached by introducing equations for the axial vibrations of the vehicle and determining their boundary conditions. A numerical example illustrating the proposed method is given. Author (GRA)

**N71-19699\*#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**A REVIEW OF THE MASS-FLUX PROBE**

Lloyd N. Krause and George E. Glawe [1971] 28 p refs Proposed for presentation at the 1971 Symp. on Flow, its Meas. and Control in Sci. and Ind., Pittsburgh, 9-14 May 1971 (NASA-TM-X-52974; E-6180) Avail: NTIS CSCL 14B

The mass-flux probe is studied as a useful diagnostic tool in high Mach number and high enthalpy flows. The factors discussed which affect the probe performance and operation include: inlet contraction ratio, shape, size, bluntness, and angle of attack. F.O.S.

**N71-19702#** Army Foreign Science and Technology Center, Washington, D.C.

**AIRPORTS: THE MILITARY POSITION OF AVIATION**

V. K. Buzunov 16 Oct. 1970 110 p refs Transl. into ENGLISH of the book 'Aerodromy: Boevaya Pozitsiya Avatsii' Moscow, 1969 p 3-124 (AD-716603; FSTC-HT-23-036-71) Avail: NTIS CSCL 1/5

The book deals primarily with military airfields, describing types, design and construction, operation and management. It discusses the functions an airfield must perform to support aviation and how an airfield is organized to carry out these functions, e.g., flight service, maintenance, armament, refueling, traffic control, etc. Author (GRA)

**N71-19706\*#** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

**ESTIMATED AERODYNAMICS OF ALL-BODY HYPERSONIC AIRCRAFT CONFIGURATIONS**

Louis J. Williams Washington Mar. 1971 38 p refs (NASA-TM-X-2091; A-3637) Avail: NTIS CSCL 01C

Results are presented for aerodynamic performance, surface temperatures, and static longitudinal and directional stability. Aerodynamic performance of the all-body configurations is presented in the form of the effect on complete configuration maximum lift-to-drag ratio of Mach number, configuration geometry, and

maximum allowable leading-edge temperature. Variations in the basic all-body shape were investigated using three independent shape parameters: body leading edge sweep, position of breakpoint between forebody and afterbody, and ratio of maximum cross section to body planform area. The third shape parameter had the strongest influence on the aerodynamic performance. Studies of the radiation equilibrium surface temperature show that the temperatures on the lower surface resulting from the inherent lift loading of the all-body configuration are less than would be expected for higher lift-loading configurations. A brief analysis of vehicle stability and control showed that using a canard for trim instead of horizontal fins reduced trim drag penalties. Author

**N71-19707\*#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**INLET PLENUM CHAMBER NOISE MEASUREMENT COMPARISON OF 20-INCH DIAMETER FAN ROTORS WITH ASPECT RATIOS 3.6 AND 6.6**

Thomas F. Gelder and Richard F. Soltis Washington Mar. 1971 49 p refs

(NASA-TM-X-2191; E-5823) Avail: NTIS CSCL 01A

The effects of rotor blade aspect ratio, part-span damper design, and hub curvature on blade passing frequency noise, multiple pure-tone noise, and broadband noise from the inlet are presented for a wide range of speeds and airflow. Facility calibrations for noise are discussed and detailed radial aerodynamic measurements were made. The higher aspect ratio reduced the noise level of blade passing frequency for all speeds; about a 9 dB reduction at 70-percent speed to about a 14 dB reduction at 100-percent speed. The reduced size of dampers along with reduced hub curvature greatly improved the aerodynamic performance of the rotor with little change in blade passing-frequency noise levels. The other two noise components were about the same for all rotors. Author

**N71-19709#** Naval Ordnance Lab., White Oak, Md.

**SUPERSONIC NOZZLE DESIGN**

Stuart L. Brodsky 22 Sep. 1970 26 p refs

(AD-716026; NOLTR-70-131) Avail: NTIS CSCL 20/4

The paper is concerned with a method of finite differences for determining two-dimensional and axisymmetric supersonic nozzle contours. The approach taken is to specify a Mach number or velocity array along the entire centerline of the nozzle and then to integrate the equations numerically to obtain the desired nozzle shape. The original problem was tested in the subsonic region, and reasonable results were found provided the Mach number gradient was not too steep in a neighborhood of the sonic line. Author (GRA)

**N71-19731#** Michigan Univ., Ann Arbor, Dept. of Naval Architecture and Marine Engineering.

**THE WAVE RESISTANCE OF AN AIR-CUSHION VEHICLE IN ACCELERATED MOTION**

Lawrence J. Doctors and Som D. Sharma Dec. 1970 199 p refs

(Contract N00014-67-A-0181-0018)

(AD-716055; Rept-099) Avail: NTIS CSCL 13/10

The report is concerned with the theoretical wave resistance of an air-cushion vehicle (ACV) traveling over water of uniform finite or infinite depth, in steady or unsteady motion. Referring first to steady motion, it is shown that the unrealistic oscillations in the wave resistance curve at low Froude numbers found by previous workers can be eliminated by using a smoothed out pressure distribution rather than one with sharp edges studied exclusively in the past. The main result of unsteady motion calculations is that the peak wave resistance in shallow water, even in moderately

accelerated motion, is appreciably less than the corresponding steady-state value. One feature of unsteady motion is that besides wave resistance there is another mechanism transferring energy to the free surface which is called the dynamic sustentation power. Contrary to intuition, the wave resistance in unsteady motion over finite depth sometimes becomes negative at supercritical Froude numbers before finally approaching zero at infinite speed.

Author (GRA)

**N71-19735#** Boeing Co., Renton, Wash. Commercial Airplane Div.

**A POTENTIAL NEW RIVET MATERIAL**

Donald Webster 18 Dec. 1970 12 p

(AD-716677; D6-24764-TN) Avail: NTIS CSCL 13/5

Additions of nickel and niobium were found to improve the ductility of AFC 77 by promoting a stress-induced austenite to martensite transformation. The combination of properties obtained in the modified alloy appear to be suitable for rivet applications.

Author (GRA)

**N71-19749#** National Aerospace Lab., Tokyo (Japan).

**ON THE AERODYNAMIC CHARACTERISTICS OF A FREE FLIGHT MODEL FFM-10**

Toshio Kawasaki, Hideo Saito, and Iwao Kawamoto Jun. 1970 53 p refs In JAPANESE; ENGLISH summary

(NAL-TR-210 Avail: NTIS

A free flight model FFM-10 equipped with NAL-7 rocket motor in the fuselage was developed for measurement of dynamic stability derivatives at subsonic and supersonic speeds. The FFM-10 has a simple configuration including a delta wing and a conical cylinder fuselage. The aerodynamic characteristics obtained from static and dynamic wind tunnel tests are discussed including a test in which a pair of ailerons and slippers were attached to the wind tunnel model.

Author

**N71-19750#** National Aerospace Lab., Tokyo (Japan).

**APPLICATION OF DORODNITSYN'S TECHNIQUE TO COMPRESSIBLE TWO DIMENSIONAL AIRFOIL THEORIES AT TRANSONIC SPEEDS**

Junzo Sato Oct. 1970 14 p refs

(NAL-TR-220T) Avail: NTIS

The approximate compressible theories of two-dimensional airfoil sections at transonic speeds were obtained by means of Dorodnitsyn's technique. Both direct and inverse methods were formulated. The singular parts of solutions were solved exactly, in terms of the incompressible flow solutions for Joukowski airfoil sections, and the remaining regular parts were transformed into a system of ordinary differential equations by means of Dorodnitsyn's integral methods; and the equations were integrated using the Runge-Kutta numerical method. An iterative cycle was set up to make the resulting profiles close in the inverse method when the pressure distributions were arbitrarily prescribed. Several examples both for direct and inverse methods were computed for symmetric airfoil sections at zero angles of attack, with the region over which the integration was made being divided into two arbitrary strips. Airfoil sections having local supersonic regions without shock waves were obtained by means of the present inverse method.

Author

**N71-19752\*#** Matrix Research, Falls Church, Va.

**HEAD-UP DISPLAYS: A STUDY OF THEIR APPLICABILITY IN CIVIL AVIATION**

Larry L. Jenney, Thomas B. Malone, and George A. Schweickert 8 Jan. 1971 326 p refs

(Contract NASw-1940)

(NASA-CR-117135) Avail: NTIS HC \$6.00/MF \$0.95 CSCL 14B

Research literature, published commentary, and supplementary information on the subject of aircraft operating problems and the head-up display are analyzed. The device presents information as a collimated image in such a way that the pilot views the display and looks out the window at the same time. The general requirements governing the display's acceptance are identified as safety, practicality, and economy. The greatest potential contribution is in approach and landing. The pilot's task and his guidance and control problems are analyzed, along with takeoff, missed approach, and taxiing in very low visibilities. The pilot's visual tasks are described in detail, and present aids and solutions to these problems and their shortcomings are examined. The applicability and usefulness of the head-up display in solving these problems are outlined. The technical and practical problems which must be solved before the display can gain final acceptance in civil aviation are classed as technological, human factors, doctrinal, and commercial. It is concluded that the potential value of the display justifies the effort necessary to resolve implementation problems.

N.E.N.

**N71-19769#** RAND Corp., Santa Monica, Calif.

**R AND D IN SOVIET AVIATION**

Arthur J. Alexander Nov. 1970 49 p refs

(Contract F44620-67-C-0045; Proj. RAND)

(AD-716410; R-589-PR) NTIS CSCL 5/3

Research, design, development, and manufacture of Soviet aircraft are concentrated in the Ministry of Aviation Industry. However, the various functions are performed by administratively separate organizations. The present structure can be traced back to 1939, when a reorganization of the industry raised a number of young individuals to positions of authority following a period of intense purges. Information flows link the separate organizations. Research institutes provide design bureaus and manufacturing plants with handbooks of aerodynamic forms and structures and lists of approved materials and manufacturing techniques. Design starts with a small, short-term effort called the pre-project, which takes only a few months to prepare. Simplicity, commonality, and design inheritance are important features of design practice.

Author (GRA)

**N71-19796\*#** Lockheed Missiles and Space Co., Huntsville, Ala. Research and Engineering Center.

**BUFFET LOAD MEASURING TECHNIQUE Final Report**

A. M. Ellison Feb. 1971 109 p refs

(Contract NAS2-5917)

(NASA-CR-114287; HREC-5917-1; LMSC-HREC-D162888) Avail: NTIS CSCL 20D

An analytical and experimental study is presented of a new technique for determining the unsteady forces during a wind tunnel test of an elastic model. The analysis showed that by placing a wind tunnel model in the feedback circuit of a servosystem which includes a force generator, a force transducer, and a model response transducer, the dynamic response of the specimen will be forced to follow the input signal. If this input command is a tape recording of the model response due to wind tunnel excitation, then the force required to reproduce the response can be used to estimate the original wind tunnel excitation forces. This force obtained from the force generator is accurately measurable with the force transducer. A control system was developed which caused the model response to closely duplicate the command signal. Good accuracy was obtained in recovering the original modal forces. The design of a servosystem based on a 50-pound thrust force generator is presented.

Author

**N71-19812#** Federal Aviation Administration, Oklahoma City, Okla. Office of Aviation Medicine.

**EVACUATION TESTS FROM AN SST MOCK-UP**

J. D. Garner and John G. Blethrow Dec. 1970 28 p  
(AA-AM-70-19) Avail: NTIS

A comparative study of passenger flow rates through Type 1 and Type A aircraft door exits was made with two 280-passenger groups from the full-scale Lockheed Supersonic Transport mock-up, mounted in a belly-landing attitude. The first load of 280 passengers and 9 crew members evacuated the mock-up through the right side containing four minimum-size Type 1 and three minimum-size Type 3 exits in 70.7 seconds. A second load of 280 passengers evacuated the left side of the mock-up containing three minimum-size Type A exits in 47.4 seconds. Each passenger group reloaded and performed another evacuation for (1) the effect on flow rates of a 12-inch increase in height of a Type 1 exit, and (2) the effect of passenger flow rates through the forward and aft Type A exits from a single aisle configuration. Effects of step-down distances outside the fuselage and influences of one and two lines to double Type A doors during escape were evaluated. Cabin crew assist spaces at double doors were under study to establish guidelines for requirements involving crew interference within passageways to the doors. An analysis of passenger intelligibility of crew commands revealed a lack of comprehension of verbal instructions. These and other influencing factors are described in the report.

Author

**N71-19817#** Boeing Co., Seattle, Wash. Military Aircraft Systems Div.

**COCKPIT GEOMETRY EVALUATION, PHASE 2. VOLUME 1: PROGRAM DESCRIPTION AND SUMMARY Final Report, 1 Jan.-21 Dec. 1969**

Patrick W. Ryan Feb. 1971 124 p refs  
(Contract N00014-68-C-0289)

(AD-716395; D162-10125-2-Vol-1, JANAIR-700201-Vol-2) Avail: NTIS CSCL 1/3

The Cockpit Geometry Evaluation Program is an experimental development to establish a standardized method for evaluating the physical geometry of a crew station. It evaluates the physical compatibility of any sized seated crew member with any crew station beginning with the design concept. Data on the geometry of the crew station, the anthropometric characteristics of the crew members, and the sequence of tasks to be performed are stored in a computer. Mathematical routines provide dynamic movement for a variable-sized mathematical man-model. Numerical performance indicators, identification of physical and visual interferences, and reach infeasibilities are output. The program was originally planned as a six-phase development. Each sophisticated phase is designed to provide an immediately usable tool. The development is highly dependent on the laboratory acquisition of identified human data requirements. Volume I summarizes the results and techniques of Phase II, and gives a sample of input and output from the computer.

Author (GRA)

**N71-19830** Aerospace Research Labs., Wright-Patterson AFB, Ohio. Hypersonic Research Lab.

**PROCEEDINGS OF THE 1969 SYMPOSIUM ON VISCOUS INTERACTION PHENOMENA IN SUPERSONIC AND HYPERSONIC FLOW**

1970 560 p refs Symp. held at Wright-Patterson AFB, Ohio, 7-May 1969

(AD-714362) Avail: HC available no charge from Issuing Activity. Attn: Maj. Morton, Bldg. 450, Wright-Patterson AFB, Ohio 45433. No copies furnished by DDC or NTIS CSCL 20/4

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**N71-19831\*#** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**SOME RECENT RESEARCH WITH VISCOUS INTERACTING FLOW IN HYPERSONIC STREAMS**

Mitchel H. Bertram and Arthur Henderson, Jr. In ARL Proc. of the 1969 Symp. on Viscous Interaction Phenomena in Supersonic and Hypersonic Flow 1970 p 1-30 refs

(NASA-TM-X-66914) Avail: NTIS CSCL 20D

Experiments are reviewed in which viscous interaction and interference predominate. This includes research on flaps at low Reynolds numbers, the flow in corners, and the flow over delta wings at high Reynolds numbers and with the addition of a body. Heat transfer and pitot and surface pressure distributions, oil flow, and the electron beam flow visualization technique are used to examine several of these interacting flow fields.

Author

**N71-19833** Princeton Univ., N.J. Gas Dynamics Lab.

**THE LAMINAR HYPERSONIC BOUNDARY LAYER: SOME OBSERVATIONS OF THE LEADING AND TRAILING EDGE PROBLEM**

S. M. Bogdonoff *In* ARL Proc. of the 1969 Symp. on Viscous Interaction Phenomena in Supersonic and Hypersonic Flow 1970 p 83-108 refs

Avail: HC available no charge from Issuing Activity. Attn: Maj. Morton, Bldg. 450, Wright-Patterson AFB, Ohio 45433. No copies furnished by DDC or NTIS

The limits of applicability of classical strong and weak hypersonic interaction theory were investigated near the leading edge and trailing edges of bodies in high-speed flows. The influence of the leading edge region was found to extend considerably downstream of the merged region. An adjustment region, extending to hypersonic interaction parameters of approximately 50 and rarefaction parameters less than 0.1, is proposed before complete reliance on hypersonic strong interaction theories is realistic. Upstream influence from the trailing edge base flow or small surface disturbances extend many boundary layer thicknesses at low Mach number and at adiabatic wall conditions but only a fraction of a boundary layer thickness at high Mach number and cold wall conditions. Correlation of the results was obtained on a boundary layer to subsonic layer thickness ratio, but further tests and analysis are required to complete the understanding of this flow phenomenon.

Author

**N71-19834\*** McDonnell-Douglas Astronautics Co., Santa Monica, Calif. Western Div.

**SUPERSONIC TURBULENT BOUNDARY LAYER INTERACTION WITH A COMPRESSION CORNER AT VERY HIGH REYNOLDS NUMBER**

A. Roshko and G. J. Thomke *In* ARL Proc. of the 1969 Symp. on Viscous Interaction Phenomena in Supersonic and Hypersonic Flow 1970 p 109-138 refs

(Contract NAS9-589)

(NASA-CR-117052) Avail: NTIS CSCL 20D

Shock wave boundary layer interaction in supersonic flow over a compression corner was investigated. The concern is more with the conditions for incipient separation, and those before separation, than with the oft-studied case of fully separated flow. The boundary layer is turbulent and at very high Reynolds numbers, which was made possible by utilizing the thick turbulent boundary layer on the wall of a large wind tunnel. The compression corner consisted of a ramp whose inclination could be varied and set during a run; this feature made it feasible to vary easily the conditions leading to incipient separation.

Author

**N71-19836** Imperial Coll. of Science and Technology, London (England). Dept. of Aeronautics.

**HYPERSONIC VISCOUS FLOW OVER CONCAVE AND CONVEX SURFACES**

J. L. Stollery *In* ARL Proc. of the 1969 Symp. on Viscous Interaction Phenomena in Supersonic and Hypersonic Flow 1970 p 181-212 refs

Avail: HC available no charge from Issuing activity. Attn: Maj. Morton, Bldg. 450, Wright-Patterson AFB, Ohio 45433. No copies furnished by DDC or NTIS

Experimental and theoretical studies of hypersonic laminar boundary layer growth over curved surfaces were made to study the effects of Reynolds number, Mach number, wall temperature, and viscous interaction on surface pressure and heat transfer rate distributions, boundary layer thickness, and separation point position. Experiments were made at  $M = 8, 12,$  and  $15$  on continuous concave and convex surfaces and on a flat plate with variable trailing edge flap. On the last of these models it was possible to study attached incipient, and well-separated flows. The incipient separation data were compared with other laminar results. By

changing the tunnel conditions, the magnitude of the viscous interaction effects was varied and the influence on surface pressure and heat transfer rate ascertained. By heating the model, the effect of wall temperature ratio was clearly demonstrated: the colder the wall, the further separation was delayed.

Author

**N71-19837** Cornell Aeronautical Lab., Inc., Buffalo, N.Y.

**THEORETICAL AND EXPERIMENTAL STUDIES OF THE SHOCK WAVE BOUNDARY INTERACTION ON CURVED COMPRESSION SURFACES**

Michael S. Holden *In* ARL Proc. of the 1969 Symp. on Viscous Interaction Phenomena in Supersonic and Hypersonic Flow 1970 p 213-270 refs

(Contract F33615-67-C-1298)

Avail: HC available no charge from issuing activity. Attn: Maj. Morton, Bldg. 450, Wright-Patterson AFB, Ohio 45423. No copies furnished by DDC or NTIS

A theoretical and experimental study of attached and separated laminar boundary layers over highly cooled, curved compression surfaces in a hypersonic airflow is described. In the theoretical study, the integral forms of the boundary-layer equations for the conservation of mass, streamwise momentum, normal momentum, moment of streamwise momentum, and energy were used to describe the development of attached and separated boundary layers on a curved surface. The theory, which was in good agreement with measurements on compression surfaces in Mach 10 and 14.8 airflows, showed that large pressure gradients can be generated across the boundary layer in the separation and reattachment regions. In the experimental study, skin friction, heat transfer and pressure measurements were made on a series of flat plate-cylindrical arc-wedge compression surfaces. Separation first occurred on the compression surface downstream of the flat plate, and incipient separation could not always be detected by observing the first occurrence of an inflexion point in the pressure distribution.

Author

**N71-19845** Aerospace Research Labs., Wright-Patterson AFB, Ohio.

**AN INVESTIGATION OF THE EXTENT OF LAMINAR TWO DIMENSIONAL BOUNDARY LAYER SEPARATION AT MODERATELY HYPERSONIC SPEEDS**

Karlheinz O. W. Ball *In* its Proc. of the 1969 Symp. on Viscous Interaction Phenomena in Supersonic and Hypersonic Flow 1970 p 551-566 refs

(Contract AF 33(615)-2175)

Avail: HC available no charge from Issuing Activity. Attn: Maj. Morton, Bldg. 450, Wright-Patterson AFB, Ohio 45433. No copies furnished by DDC or NTIS

Results of an experimental investigation are presented for the behavior of laminar boundary layers on a compression corner model simulating a lift surface followed by a control surface. The effect of model span and chord length is discussed to obtain fully developed regions of separation and consistent data. The experimental data is compared with an analytic approach for the prediction of the beginning of the separation interaction. Generally good agreement was obtained permitting further development of the effects of Mach number, Reynolds number, heat transfer, and flap deflection angle on the extent of separation. Possible extension of the analysis to turbulent boundary layers is indicated.

Author

**N71-19848#** Lincoln Lab., Mass. Inst. of Tech., Lexington.

**A COCKPIT SITUATION DISPLAY OF SELECTED NAS/ARTS DATA**

Richard W. Bush, Howard Blatt, and Francis X. Brady 15 Dec. 1970 22 p

(Contract F19628-70-C-0230)

(AD-716425; TN-1970-39; ESD-TR-70-404) Avail: NTIS CSCL 17/7

By the mid-1970s, the evolving NAS/ARTS ground environment will provide the air traffic controllers with high quality computer-processed traffic situation displays. We believe it would be useful, particularly in busy terminal areas, to display some of this data in the cockpit. Systems with this objective have been constructed and flight tested at least 3 times during the past 25 years, but these earlier systems could not benefit from: a source of computer-processed data of the quality to be available from NAS/ARTS; aircraft altitude information; contemporary digital data link techniques; and airborne equipment capable of automatically selecting and displaying only information relevant to a particular airplane. It is believed that an effective cockpit display would permit pilots, under IFR conditions, to retain some of the station-keeping and navigation functions they perform during VFR conditions and thereby improve the efficiency of terminal area operation. The goals of the proposed program are: to evaluate the effectiveness of this class of system in reducing pilot and controller work loads, and to determine its potential for expediting traffic flow in busy terminal areas. A simulated cockpit display has been developed and experienced pilots and controllers who have flown it have endorsed enthusiastically the desirability of evaluating this class of system in an operational environment. Author (GRA)

**N71-19853\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**EXPERIMENTAL INVESTIGATION OF THE INTERACTION OF A NACELLE-MOUNTED SUPERSONIC PROPULSION SYSTEM WITH A WING BOUNDARY LAYER**

Glenn A. Mitchell and David F. Johnson. Washington. Mar. 1971. 42 p refs

NASA-TM-X-2184; E-5983. Avail: NTIS CSCL 20D

A Mach 2.5 inlet nacelle was mounted adjacent to a simulated wing boundary layer. The extent of inlet shock and boundary layer interactions was determined for steady state inlet operation and unstart transients. Transients were initiated with bypass closure and throat overcontraction for an inlet coldpipe combination, the inlet with a choke point at the compressor face station, and the inlet mated to a J85-GE-13 turbojet engine. Engine stalls were also used to initiate transients. The effects of boundary layer height and wing-to-cowl-lip spacing were determined. The most severe transients were those resulting from engine stalls which produced wing-boundary-layer separations extending 2.8 cowl-lip diameters forward of the lip. Author

**N71-19856#** Michigan Univ., Ann Arbor. Dept. of Naval Architecture and Marine Engineering.

**ELASTIC STRENGTH OF PROPELLERS: AN ANALYSIS BY MATRIX METHODS Final Report**

Paris Genalis (Ph.D. Thesis) Nov. 1970. 219 p refs (Contract N00014-67-A-0181-0017)

(AD-716463; Rept-101) Avail: NTIS CSCL 13/10

The determination of displacements and stresses in a propeller blade under the influence of a hydrodynamic pressure load is investigated. Also a simplified approach to the free, undamped vibration of the blade is suggested. The finite element method of analysis is used to analyze the blade as a shell or as a combination of a three dimensional solid and a shell. For the vibration problem, the complete blade was idealized by shell elements only. Constant stress tetrahedra and rectangular prism elements were used for the analysis of the three dimensional solids. A combination of both kinds of elements was found to cause no algorithmic difficulties or inaccuracies in the results and to provide the flexibility to approximate irregular boundaries by the tetrahedron. The stiffness of the shell element was obtained by the superposition of the stiffness of the plane stress element and the fully compatible plate bending element. The results using only the shell element were

good both for the static and the dynamic problems. It was felt that with comparable meshes the shell element was more powerful than either of the three dimensional elements. Author (GRA)

**N71-19857#** National Aeronautical Establishment, Ottawa (Ontario).

**A FRACTOGRAPHIC STUDY OF THE FATIGUE FAILURE OF AIRCRAFT WHEELS**

W. Wiebe. Nov. 1970. 46 p refs

(NRC-11694; LR-541) Avail: NTIS

A survey of aircraft wheel failures, and a review of the parameters involved in the qualification tests for aircraft wheels, have indicated a need for accurate information concerning wheel service loading conditions in order to formulate realistic wheel fatigue test spectra. The fractographic examination of three types of wheels from modern aircraft has emphasized the significance of corrosion in the nucleation of fatigue cracks, and has indicated that landing impact loads and brake applications at high speeds may contribute to the growth of the cracks. Several types of macroscopic growth bands or lines that are frequently observed on the fatigue fracture surfaces of laboratory specimens and of components that have failed in service, have been cited and described. Those lines observed on the fracture surfaces of the failed wheels were correlated with crack growth during aircraft landing cycles. The derivation of fatigue crack growth rate information from these lines has facilitated the revision of wheel inspection schedules with the purpose of preventing the catastrophic failure of aircraft wheels. Author

**N71-19865#** Rhode Island State Planning Program, Providence. STATE AIRPORT SYSTEM AIRLINE PASSENGER TICKET SURVEY

Oct. 1970. 19 p refs. Supplement to PB-195939. Its Tech. Paper No. 17, Suppl. 1

(PB-195940) Avail: NTIS CSCL 01E

The document is a supplement which summarizes the second phase of an airline passenger ticket survey. The format of the survey and a summary of the first phase was reported in N71-19611. The present survey was carried out in an identical manner. Author (GRA)

**N71-19901#** National Aviation Facilities Experimental Center, Atlantic City, N.Y.

**TITANIUM FUSELAGE ENVIRONMENTAL CONDITIONS IN POST-CRASH FIRES Final Report, 1968-1970**

Constantine P. Sarkos. Mar. 1970. 74 p refs

(FAA-RD-71-3; FAA-NA-71-2) Avail: NTIS

A 28-foot titanium fuselage was exposed to a 400-square-foot JP-4 fire for about 2 1/2 minutes. The titanium fuselage remained intact, thus preventing any flames from entering into the cabin. Heating of the cabin pressure sealant and insulation caused these materials to burn. This, in turn, caused significant increases in temperature, smoke, and toxic and combustible gases within the cabin at about one minute after fuel ignition and a flash fire at two minutes. Theoretical heat transfer calculations were compared with thermocouple data from a section of the fuselage where the insulation did not burn. This comparison indicated that if the insulation and sealant were inert, habitable conditions would have been maintained within the cabin for at least five minutes, and perhaps more. Author

**N71-19908#** Naval Civil Engineering Lab., Port Hueneme, Calif. SNOW COMPACTION: INVESTIGATION OF METAMORPHISM OF SNOW Final Report, Jun. 1968-Jun. 1970

N. S. Stehle Dec. 1970 31 p refs  
(AD-716417; TR-706) Avail: NTIS CSCL 8/12

Although processing and compacting increase the density and bearing capacity of surface snow for use as roads and trails, these processes have not been able to achieve the degree of densification that occurs naturally as snow slowly metamorphoses to glacier ice. A study was made at the Naval Civil Engineering Laboratory of the processes and influences of the major mechanisms that control snow metamorphism--grain size, pressure, temperature and solar radiation--in order to provide a basis for developing better techniques for higher strength snow pavements. It was concluded that maximum snow strengths are achieved at or near a critical density of 60 gm/cu cm, followed by bond growth, or age hardening, at temperatures between -12C and -7C. In addition, as distribution of applied loads with depth is essential to the development of operational criteria for such pavements, it is recommended that research be conducted to develop this knowledge.

Author (GRA)

**N71-19912\*#** Cornell Aeronautical Lab., Inc., Buffalo, N.Y.  
**A SECOND ORDER SLENDER WING THEORY FOR WINGS WITH LEADING EDGE SEPARATION**

Joseph P. Nenni and Chee Tung Apr. 1969 45 p refs  
(Contract NAS1-7650)

(NASA-CR-66762; CAL-BB-2530-5-1) Avail: NTIS CSCL 20D

A second-order, slender-wing theory was developed for incompressible flow over low-aspect-ratio wings with and without leading-edge separation. The theory is second order in terms of the ratio of span to chord which is proportional to aspect ratio. The theory has been developed using the technique of matched asymptotic expansions. The Brown and Michael flow model was used for the case with leading-edge separation. The theory proves to be somewhat limited in that it can only be reasonably applied to wings which satisfy the Kutta condition at the trailing edge in the first approximation. The present results obtained for an aspect-ratio-one gothic wing represent a significant improvement for the separated flow case over the first-order result but the predicted lift is still somewhat higher than the experimental data. Author

**N71-19921#** Sandia Corp., Albuquerque, N.Mex. Technical Translation Service.

**SOME RECENT RESULTS OF RESEARCH CARRIED OUT AT ONERA ON MECHANICS OF SOLIDS [QUELQUES RESULTATS RECENTS DES RECHERCHES EFFECTUEES A L'ONERA EN MECHANIQUE DES SOLIDES]**

Roger Valid Apr. 1970 21 p refs Transl. into ENGLISH from Rech. Aerosp. (France), no. 2, Mar.-Apr. 1970 p 113-119 Presented at Natl. Conf. of Appl. Mech., Bucharest, 23-27 Jun. 1969 Sponsored by AEC

(SC-T-70-4047; CONF-690647-1) Avail: NTIS

Calculating methods are discussed for elementary structures, such as shells and beams, working outside the elastic domain. Three-dimensional behavior laws, in plasticity as well as in creep are considered. The studies proceed along two lines: (1) development and checking of behavior laws, and (2) development of calculation methods. Author

**N71-19952#** Aix-Marseilles Univ. (France). Inst. de Mecanique des Fluides.

**THEORETICAL AND EXPERIMENTAL STUDIES OF A HIGH TEMPERATURE HYPERSONIC BOUNDARY LAYER WITH AN ADVERSE PRESSURE GRADIENT [ETUDE THEORIQUE ET EXPERIMENTALE D'UNE COUCHE LIMITE HYPERSONIQUE CHAUDE EN PRESENCE D'UN GRADIENT DE PRESSION DEFAVORABLE]**

R. Marmey, J. P. Guibergia, and E. Brocher Jul. 1970 69 p refs In FRENCH  
(Contract DRME-516/68)

Avail: NTIS

Boundary layer interactions with nonviscous outflows of hypersonic or supersonic air inlets are reported. A computer program was used to analyze aerodynamic interaction data of conical pointed axisymmetric bodies of revolution having differing curvatures, in high- and low-enthalpy shock tunnel tests. Shock values were determined from convective heat flow distributions and pressures on the wall. Results established the formation of a weak shock wave between the conical point and the conical envelope; this shock wave was refracted and detached and produced upon collision with an obstacle a laminar boundary layer until it reattached to the envelope again. Convective heat flux distribution on the envelope was a cross function between curvature and Reynolds number.

Transl. by G.G.

**N71-20002#** Advisory Group for Aerospace Research and Development, Paris (France).

**A LITERATURE SURVEY ON THE GYROSCOPE AND ITS APPLICATIONS**

Helmut Sorg (Stuttgart Univ.) Feb. 1971 23 p refs  
(AGARD-582-71) Avail: NTIS

A consolidated listing is presented of all known unclassified texts which are readily available to scientists and engineers from commercial sources, documentation centers and public as well as corporate libraries. Each entry cites the author, publication year, title, documentation center source and a brief abstract of the work.

Author

**N71-20040\*#** Virginia Univ., Charlottesville. Research Labs. for the Engineering Sciences.

**RESEARCH IN THE FIELD OF MOLECULAR COLLISION PHENOMENA USING MOLECULAR BEAM TECHNIQUES Final Report**

S. S. Fisher, A. R. Kuhlthau, and J. E. Scott, Jr. Feb. 1971 22 p refs

(Grant NGR-47-005-046)

(NASA-CR-117041; AEEP-4038-115-714) Avail: NTIS CSCL 20H

The application of modern molecular beam techniques to the study of molecular collision processes is reported. Emphasis has been placed on interactions between atmospheric gases and solid surfaces. Investigations have been primarily experimental observations of the scattering of gases from engineering surfaces in the thermal range of interaction energies. Aerodynamic-type molecular beams are employed. After a beam is scattered from a test surface, the angular distribution of beam flux and the distribution of velocities in that flux are measured. These distributions then characterize the interaction. Author

**N71-20050\*#** Massachusetts Inst. of Tech., Cambridge. Fluid Mechanics Lab.

**SMOKE EMISSION FROM JET ENGINES**

Lawrence H. Linden and John B. Heywood Oct. 1970 32 p refs Sponsored in part by NSF

(Grant NGR-22-009-378)

(NASA-CR-117031; FML-70-12) Avail: NTIS CSCL 21E

The fundamental processes determining the amount of smoke in the exhaust of a gas turbine engine are examined. The configuration of modern combustors and the processes occurring within the combustor are reviewed. Data from laboratory flame studies of carbon formation are then discussed and correlated with engine and combustor exhaust studies. It is seen that solid carbon is the nonequilibrium product of fuel vapor-air combustion in locally fuel rich zones. Calculations of carbon oxidation rates are then used to show that significant fractions of the carbon formed in the rich

regions of the primary zone may be consumed in the leaner regions of the primary zone and in the secondary zone. Finally, combustor design features desirable for minimal exhaust smoke are summarized. Author

**N71-20051#** Advisory Group for Aerospace Research and Development, Paris (France).

#### ASSESSMENT OF LIFT AUGMENTATION DEVICES

Feb. 1971 284 p refs Presented at the Lecture Series, Rhode-Saint-Genese, Belgium, 20-24 Apr. 1970; Sponsored by AGARD and von Karman Inst. (AGARD-LS-43-71) Avail: NTIS

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**N71-20052#** Hawker Siddeley Aviation, Ltd., Hatfield (England), Aerodynamic Dept.

#### AERODYNAMICS OF MECHANICAL HIGH LIFT DEVICES

D. M. McRae /in AGARD Assessment of Lift Augmentation Devices Feb. 1971 23 p refs  
Avail: NTIS

The purpose is to describe in general terms the stalling of conventional airfoils and the effects of mechanical high lift devices thereon. The factors affecting maximum lift coefficient are discussed in the context of estimation methods. Drag is also discussed. Author

**N71-20053#** Technische Hochschule Carolo Wilhelmina, Brunswick (West Germany). Inst. für Stromungsmechanik.

#### AERODYNAMICS OF PNEUMATIC HIGH LIFT DEVICES

J. von der Decken /in AGARD Assessment of Lift Augmentation Devices Feb. 1971 36 p refs  
Avail: NTIS

An introductory survey of pneumatic boundary layer and circulation control schemes for increasing maximum lift is given. The physical background of boundary layer control by suction and blowing, and of supercirculation and slipstream effects, is described; also the aerodynamic efficiency of the different devices is estimated by theoretical approaches. Finally, practical applications and performance evaluation of pneumatic devices are discussed. Author

**N71-20054#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France). Dept. des Etudes de Synthèse.

#### AERODYNAMICS OF VARIABLE SWEEP

Ph. Poisson-Quinton /in AGARD Assessment of Lift Augmentation Devices Feb. 1971 19 p refs  
Avail: NTIS

Aerodynamic problems in the design of variable sweep aircraft are discussed. Selection of pivot location is reviewed, as well as investigations of high lift devices, wing camber, and longitudinal instability near the stall on variable sweep configurations. Application of this configuration to reusable spacecraft is mentioned. E.C.

**N71-20055#** von Karman Inst. for Fluid Dynamics, Rhode Saint-Genese (Belgium).

#### FUNDAMENTAL ASPECTS OF FLOW SEPARATION UNDER HIGH LIFT CONDITIONS

H. P. Horton /in AGARD Assessment of Lift Augmentation Devices Feb. 1971 19 p refs  
Avail: NTIS

A qualitative description is presented of separation problems covering: two dimensional laminar and turbulent separation concepts, separated flow on single two dimensional airfoils, boundary layer separation bubbles, separated flow on multi-airfoil systems (wake and boundary layer mixing), and three dimensional separated flow. The possibility of applying theoretical techniques to the prediction of the maximum lift and drag of an airfoil is briefly discussed. E.C.

**N71-20056#** National Lucht-En Ruimtevaartlaboratorium, Amsterdam (Netherlands).

#### SOME NOTES ON TWO DIMENSIONAL HIGH LIFT TEST IN WIND TUNNELS

B. van den Berg /in AGARD Assessment of Lift Augmentation Devices Feb. 1971 18 p refs  
Avail: NTIS

Problems associated with two dimensional high lift tests are discussed in terms of the test setup in the wind tunnel, the design of the models, and the methods to determine the forces on the model. Tunnel wall interference effects are also discussed. These include the effect of the constraint which the tunnel walls impose on the flow as well as the danger of boundary layer separations on the tunnel walls. The necessity of boundary layer control at the model tunnel wall junctions is demonstrated. Author

**N71-20057#** British Aircraft Corp., Warton (England). Wind Tunnel Dept.

**MODEL TESTING REQUIREMENTS AND TECHNIQUES FOR HIGH LIFT SCHEMES: THREE DIMENSIONAL ASPECTS**

C. Russell *In* AGARD Assessment of Lift Augmentation Devices Feb. 1971 22 p refs

Avail: NTIS

The subject of three-dimensional high lift model testing is dealt with from the point of view of the development of a specific full-size project. Various topics and problems are dealt with, in approximately the order in which they would normally arise, from initial concept to data presentation. Author

**N71-20058#** Boeing Co., Seattle, Wash.

**ANALYSIS OF TRANSPORT APPLICATIONS FOR HIGH LIFT SCHEMES**

L. B. Gratzner *In* AGARD Assessment of Lift Augmentation Devices Feb. 1971 23 p refs

Avail: NTIS

The way in which the design tradeoff process affects airplane economics is illustrated in relation to the impact of high lift system design on the final configuration selection. An assessment of representative high lift concepts, including boundary layer control, is given in terms of low-speed performance potential. For long-range transport airplanes operating from long runways, it is shown that well-designed mechanical flap systems are generally competitive with more sophisticated concepts involving blowing or suction boundary layer control (BLC). However, recent progress in high lift technology indicates that significant performance gains for long-range airplanes may be possible using BLC techniques. The gains for airplanes designed to operate from shorter fields appear attractive and achievable with today's technology. For STOL airplanes the use of BLC to provide high wing lift together with direct lift from the engines, or a more highly integrated form of lift augmentation such as the jet flap, is mandatory. The interaction between high lift system design and problems involving the stability and control characteristics of the airplane are considered. Author

**N71-20059#** Breguet-Aviation, Velizy (France). Div. Aerodynamique.

**ANALYSIS OF COMBAT AIRCRAFT APPLICATIONS FOR LIFT AUGMENTATION DEVICES**

R. Taisseire *In* AGARD Assessment of Lift Augmentation Devices Feb. 1971 21 p

Avail: NTIS

Problems associated with the design of high lift systems for combat aircraft are reviewed. Performance and flying qualities are considered. Low level high speed flying requires small wing thickness to chord ratio (about 5 to 7%), high sweep angle (35 to 45 degs), small aspect-ratio (3 to 4) and high wing loadings (about 400 to 500 kg per sq. meter). With such a wing, it is difficult to provide good take-off and landing performance for short field operation while maintaining good flying qualities at low speeds. Effective high lift devices are needed to achieve the low stalling speeds required for short takeoff and landing distances and their design must provide a satisfactory level of control in the low speed flight range. The review is intended to clarify the problems encountered in achieving these aims and to indicate ways of solving them. Author

**N71-20060#** Aeroplane and Armament Experimental Establishment, Boscombe Down (England). Performance Div.

**FLIGHT TESTING MILITARY TRANSPORT AIRCRAFT FOR CLEARANCE IN THE STOL ROLE**

K. P. Eyre *In* AGARD Assessment of Lift Augmentation Devices

Feb. 1971 24 p ref

Avail: NTIS

The types of tests which are likely to be required to clear an aircraft from handling and performance aspects for military STOL applications are discussed. Tests made to clear the Andover C. Mk. 1 are given as an example. No special consideration is given to particular high lift devices each of which may of course introduce individual problems. However, it is considered that in the case of STOL aircraft generally the problem of variability in behavior may require more than usual attention due to the rapid maneuvers and short distances involved with considerable dependence on pilot technique. Author

**N71-20061#** Rolls-Royce, Ltd., Bristol (England). Bristol Engine Div.

**LIFT AUGMENTATION DEVICES AND THEIR EFFECT ON THE ENGINE. PART 1: INTERFACE PROBLEMS BETWEEN ENGINE AND AIRFRAME**

J. A. Hooper *In* AGARD Assessment of Lift Augmentation Devices Feb. 1971 18 p

Avail: NTIS

Interface problems between engine and airframe associated with the achievement of short field performance are described. Civil and military aircraft are treated with the main emphasis on civil STOL. A range of possible lift augmentation devices is considered, and their effect on engine design is shown. The associated problems of noise and performance are also considered. Optimum engine designs and their particular characteristics for various systems are described. Author

**N71-20062#** Rolls-Royce, Ltd., Bristol (England). Bristol Engine Div.

**LIFT AUGMENTATION DEVICES AND THEIR EFFECT ON THE ENGINE. PART 2: THERMODYNAMIC PROBLEMS AND SOME POSSIBLE SOLUTIONS**

E. A. White and H. C. Hillier *In* AGARD Assessment of Lift Augmentation Devices Feb. 1971 13 p

Avail: NTIS

The effects of the previously established design criteria on the thermodynamics of the engines for STOL applications are discussed. Several possible engine solutions with their associated advantages and disadvantages are described. Author

**N71-20063#** Lockheed-Georgia Co., Marietta.

**OPTIMISING THE PROPULSIVE/LIFT SYSTEM FOR TURBOFAN STOL AIRCRAFT CONSIDERING COST EFFECTIVENESS**

H. T. Bowling *In* AGARD Assessment of Lift Augmentation Devices Feb. 1971 14 p

Avail: NTIS

The results are presented of a comparison of three STOL high lift concepts which have been integrated with bypass-ratio turbofan engines. Transport aircraft configurations optimized using these concepts are compared along with significant characteristics of each system. The purpose of this comparison was to provide possible insight for future studies and testing. None of these systems were subjected to a highly detailed analysis and do not represent completely optimized concepts. Every effort was made to make the comparison as consistent as possible. A secondary purpose is the discussion and demonstration of a study methodology which was developed to integrate cost effectiveness into the early technical development of new airplane concepts. This methodology is primarily applied to a military STOL development program. However, some examples are shown of considerations of commercial cost effectiveness. Author

**N71-20064#** Office National d'Etudes et de Recherches Aeronautiques, Paris (France).

**A NEW TECHNIQUE FOR AEROFOIL LEADING EDGE STUDIES**

J. Monnerie /In AGARD Assessment of Lift Augmentation Devices Feb. 1971 5 p ref

Avail: NTIS

Illustrations are given from an investigation of flow separation bubbles which develop near an airfoil leading edge. These include a drawing of the airfoil profile, a velocity diagram for a profile with a Handley Page slat, a plot of the similarity between the flow on two models, surface flow visualization near the leading edge, boundary layer curves in the bubble region, and water tunnel model visualization data. E.C.

**N71-20065#** Royal Aircraft Establishment, Farnborough (England).  
**SOME COMMENTS ON CHARACTERISTICS OF HIGH LIFT WINGS**

D. N. Foster /In AGARD Assessment of Lift Augmentation Devices Feb. 1971 5 p refs

Avail: NTIS

Wind tunnel tests, under as near to two dimensional conditions as possible, were carried out on a wing section with plain leading and trailing edge flaps having boundary layer control by blowing at the flap knees. A range of flap deflections were tested; results are presented for the condition with no leading edge flap deflection and with the trailing edge flap deflection 20 deg. Results suggest that the inviscid lift is achievable with a momentum coefficient which is dependent on the angle of incidence (or the lift); that under these conditions a pressure distribution will be measured which is very similar to the inviscid predictions; and that sensibly zero drag will result. Drag with high lift devices is also discussed. Author

**N71-20066#** Hawker Siddeley Aviation, Ltd., Hatfield (England).  
**THE HUNTING H-126 JET FLAP RESEARCH AIRCRAFT**

K. D. Harris /In AGARD Assessment of Lift Augmentation Devices Feb. 1971 7 p refs

Avail: NTIS

The jet flap principle is reviewed, as well as the development of a piloted research aircraft to test the principle. Aircraft thrust losses, stability and control problems, and stalling characteristics are discussed. E.C.

**N71-20067#** Canadair, Ltd., Montreal (Quebec).  
**AERODYNAMIC RESEARCH ON HIGH LIFT SYSTEMS**

Fotis Mavriplis /In AGARD Assessment of Lift Augmentation Devices Feb. 1971 13 p refs

Avail: NTIS

Aspects of two dimensional flow research on high lift systems are discussed. A theoretical method is described for calculating two dimensional potential flow about multi-element high lift airfoils. The method is based on the distribution of vorticity on the airfoil contour. A wall blowing technique is also described which was developed for testing effectively complex high lift models in the wind tunnel. It was used to study the effect of leading edge and trailing edge devices on the aerodynamic characteristics of a 17% and a 10% thick airfoil. Finally, comparisons of calculated and experimental data obtained on some of the complex configurations tested are presented to demonstrate the usefulness of the methods described. Author

**N71-20068#** Douglas Aircraft Co., Inc., Long Beach, Calif.  
**DEVELOPMENT OF A BASIC METHODOLOGY FOR PREDICTING AIRCRAFT STOPPING DISTANCE ON A WET RUNWAY** Final Report, 1966 1970

O. W. Preston, G. W. Kibbee, R. H. Muroyama, and R. A. Storley Mar. 1971 19 p refs

(Contract DOT-FA-66-NF-128)

(FAA-NA-70-5; FAA-RD-70-62) Avail: NTIS

Studies and tests were conducted to develop a basic methodology for predicting the test aircraft stopping distance on a wet runway. Development consisted of a series of wet and dry runway tests utilizing the FAA Variable Slip Runway Friction Tester and an instrumented nonflyable test aircraft followed by an analysis of the test results using an analog computer simulation of the aircraft. A relationship was established between wet runway friction measured by the friction tester and friction available to the braking wheels of the test aircraft. The methodology consists of using this relationship and an analog computer aircraft simulation, incorporating actual antiskid and braking system hardware, to prepare a nomograph showing aircraft stopping distance as a function of the runway friction measured by the FAA Variable Slip Runway Friction Tester. Correlation exists between friction measured by the friction tester and friction available to the tires of the test aircraft when normalized with respect to theoretical hydroplaning velocities. Author

**N71-20069#** National Aviation Facilities Experimental Center, Atlantic City, N.J.  
**INVESTIGATION OF THE EFFECTS OF RUNWAY GROOVES ON WHEEL SPIN-UP AND TIRE DEGRADATION** Final Report, Nov. 1969 Mar. 1970

Charles R. Grisel Apr. 1971 26 p

(FAA-RD-71-2; FAA-NA-70-47) Avail: NTIS

Tests were conducted at three airports having different runway groove configurations. The objective of these tests was to determine if grooves change the rate of wheel spin-up and if they produce cuts in the tires of the test aircraft. Although no evidence of tire cutting was observed, it was found that the wheel spin-up rate for the test aircraft was increased by the runway grooves. The extent of the increase was influenced by the width of the grooves. Author

**N71-20101#** National Aerospace Lab., Tokyo (Japan).  
**A CALCULATION OF THE PROFILE DRAG OF AIRFOILS AT LOW MACH NUMBERS**

Toshio Kawasaki and Yoichi Ishida 1970 19 p refs In JAPANESE; ENGLISH summary

(NAL-TR-198) Avail: NTIS

A method for calculating the profile drag of airfoils at low Mach numbers is presented. In this method the calculated or experimental pressure distributions on airfoils must be given in advance. The method consists of 1) calculation of laminar boundary layer by Thwaites' method, 2) prediction of instability point by Schlichting-Urtich's correlation curve, 3) prediction of transition point by Granville's correlation curve, 4) calculation of turbulent boundary layer by Head's method, and 5) calculation of wake by means of the Squire-Young relation. The procedure that predicts the instability point first and then predicts transition point seems to be more reasonable from the physical point of view. In this method, an approximate treatment of laminar separation bubbles which occur near the leading edge of airfoils was also studied. It was shown that an approximation is reasonable, at least to the short bubbles. Profile drag has been calculated by this method for several airfoils at various lift coefficients and Reynolds numbers. Comparison of the results with available experimental data show good agreement. The error based on calculated drag values is 3.7% Author

**N71-20102#** National Aerospace Lab., Tokyo (Japan).  
**ANALYTICAL AND SIMULATION STUDIES ON THE HEIGHT CONTROL SYSTEM OF FLYING TEST BED. 2: ON SOME PROBLEMS**

Yuso Horikawa and Tadao Kai 1970 46 p refs In JAPANESE, ENGLISH summary  
(NAL-TR-200) Avail: NTIS

For the purpose of studying the fundamental problems of VTOL operations for lift jet type VTOL aircrafts, a flying test bed (FTB) has been developed. The analytical and simulation studies have been done with a flight simulator consisting of an analog computer and a simple fixed base cockpit, and criteria of these studies were not based on the pilot rating system but the quantitative analysis of simulation results. Operational problems which were analyzed and these results are as follows. (1) safety problems when one engine out in flight, (2) effect of transient response when redundant triple systems change over from the normal system to the standby system, (3) effect of attitude motion on height control, (4) effects of nonlinearities, and (5) effect of vertical gust in flight.

Author

**N71-20106#** National Aerospace Lab., Tokyo (Japan).  
**LOW SPEED WIND TUNNEL-TESTS OF THE FA-200-XS AIRPLANE MODEL INFLUENCED WITH GROUND EFFECTS**  
Kenichi Hirose, Takatugu Ono, Hiroshi Takahashi, and Naoki Kuwano 1970 35 p refs In JAPANESE, ENGLISH summary  
(NAL-TR-201) Avail: NTIS

Tests were conducted in a 6 m. low-speed wind tunnel for the investigation of the effects of ground proximity on the static longitudinal characteristics of the FA-200-XS airplane model. The ground was simulated by a moving-belt test rig. The tests described cover cases of flap deflection with boundary layer control at power on and power off conditions. The effectiveness of elevator at ground proximity was also investigated.

Author

**N71-20109#** California Univ., Livermore. Lawrence Radiation Lab.

**CLOSER TOLERANCES: ECONOMIC SENSE**

James B. Bryan 17 Mar. 1970 20 p Presented at the 1970 Gen. Assembly CIRP, Turin, 28 Aug.-6 Sep. 1970 Submitted for publication Sponsored by AEC  
(UCRL-72380; CONF-700831-1) Avail: NTIS

The economics of closer tolerances in manufacturing are discussed. Examples show that improvements can be made in the following areas of consumer interest: reduced initial cost, reduced operating cost, increased lifetime, increased reliability, increased performance, reduced undesirable side effects, ease of use, better portability and durability through miniaturization, ease of repair through the use of fewer parts which are interchangeable, and improved appearance. The principle example used in support of this contention is a model airplane engine costing less than \$6.00, which routinely holds a tolerance of 50 microinch on the clearance between the piston and cylinder.

Author

**N71-20114\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**AN ECONOMIC ANALYSIS OF FUTURE SHORT-HAUL TRANSPORTATION**

George C. Kenyon, Thomas L. Galloway, and Hubert M. Drake Washington Mar. 1971 62 p refs  
(NASA-TM-X-2228; A-3727) Avail: NTIS CSCL 05C

A simplified economic analysis has been made of one transportation mission: intercity short-haul business passenger-travel. The analysis includes both air and ground transportation modes for 1968 based on current mode characteristics, and for 1975 and 1982 based on projected characteristics for two assumed levels of R&D. The effects of changes in the transportation mode and interface characteristics are investigated. The simplified approach allowed a qualitative assessment of the relative merits of transportation modes. Specifically, the results for 1968 indicated that the auto, bus, and subsonic jet were competitive while the train

was not. The helicopter could be competitive at ranges between 50 and 150 miles for time values above \$5/hour. The light aircraft was particularly attractive for multiple travelers. Results for 1975 and 1982 indicated that: (1) the auto will remain the major mode for short distances; (2) the bus will remain competitive at low time values; (3) the high speed train will not be competitive unless heavily subsidized; and (4) the STOL transport will be a major transportation mode until it is replaced by the VTOL. An intensive level of R&D effort will be required to produce a competitive VTOL transport by 1982. The light aircraft mode, particularly with STOL performance and multiple travelers, appears very promising.

Author

**N71-20115#** Loughborough Univ. of Technology (England). Dept. of Transport Technology.

**CALCULATION OF THE THREE-DIMENSIONAL POTENTIAL FLOW AROUND LIFTING NON-PLANAR WINGS AND WING-BODIES USING A SURFACE DISTRIBUTION OF QUADRILATERAL VORTEX-RINGS**

B. Maskew Sep. 1970 80 p refs  
(TT-7009) Avail: NTIS

A numerical method for calculating the steady three-dimensional potential flow around lifting nonplanar configurations is outlined and a number of preliminary results presented which demonstrate the potentially wide range of application. The method is based on a surface distribution of quadrilateral vortex-rings. Each quadrilateral element has a control point at which the boundary condition of zero flow (vortex-induced plus free stream) through the surface is specified. The vortex-ring strengths are solved after evaluating all the vortex-ring influence coefficients for each control point in turn and applying the boundary condition. The vortex strengths are then used to obtain surface velocities, pressures, loads and moments. The results which are presented include some for cases involving wing alone (thin and thick), wing plus flaps (plain flaps and slotted flaps), wing-fuselage and wing in wind-tunnel.

Author

**N71-20126\*#** National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

**ROLL-CONTROL EFFECTIVENESS OF SEVERAL SPOILER CONFIGURATIONS ON AN AIRPLANE MODEL WITH WING SWEEP OF 55 DEG AND 75 DEG AT SUPERSONIC MACH NUMBERS**

Clyde Hayes Washington Mar. 1971 64 p refs  
(NASA-TM-X-2165; L-7177) Avail: NTIS CSCL 01A

An investigation has been conducted to determine the roll-control effectiveness of several spoiler configurations on an airplane model employing variable-sweep wings. The spoilers were located on either the movable outer wing panel or the fixed inboard panel. Leading edge extensions, deflected to provide roll control, were also investigated. The outboard-spoiler tests were made at Mach numbers from 2.50 to 4.63 at a constant Reynolds number of 3 million per 0.3048 meter (per foot). The inboard spoilers and leading-edge extensions were tested at Mach numbers from 1.50 to 2.86 at a constant Reynolds number of 2 million per 0.3048 meter (per foot). The results of the investigation showed that although the effectiveness of all the upper surface spoilers was small, there were configurations that produced rolling moments probably sufficient to trim the configuration and allow some maneuvering at low angles of attack. Lower wing-surface spoilers, inboard upper surface spoilers, and leading-edge extensions were all ineffective in producing significant amounts of rolling moment over the range of Mach number and angle of attack. Reversal of the direction of rolling moment with changing Mach number occurred with inboard spoilers.

Author

**N71-20127\*#** Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.

**TWO-DIMENSIONAL, SUPERSONIC MIXING OF**

**HYDROGEN AND AIR NEAR A WALL**

Charlie L. Yates Washington NASA Mar. 1971 46 p refs  
(Contract NASr-76)

(NASA-CR-1793) Avail: NTIS CSCL 20D

Parallel injection of hydrogen at Mach 1.19 from a rectangular wall-slot into a Mach 2.1 airstream was experimentally investigated using instream probes. The development of pressure, temperature, composition and velocity profiles was measured to a downstream distance of 30 slot heights for two values of the hydrogen-to-air mass flux ratio: 0.088 and 0.120. From the data, there are determined the growth rates of the turbulent species, energy and momentum transfer layer thicknesses, and the decay rates of the composition, temperature and velocity maxima. The attainment of self-similarity in the case of species transfer is also examined.

Author

**N71-20128#** Advisory Group for Aerospace Research and Development, Paris (France).

**STRUCTURAL DESIGN APPLICATIONS OF  
MATHEMATICAL PROGRAMMING TECHNIQUES**

G. G. Pope and L. A. Schmit, eds. Feb. 1971 203 p refs  
(AGARD-AG-149-71; AGARDOGRAPH-149) Avail: NTIS

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**N71-20129#** Advisory Group for Aerospace Research and Development, Paris (France).

**INTRODUCTION AND BASIC CONCEPTS**

L. A. Schmit and G. G. Pope *In its* Structural Design Appl. of Mathematical Programming Tech. Feb. 1971 p 2-13 refs

Avail: NTIS

The application of mathematical programming methods to aerospace structural design is discussed. The fundamental ideas are illustrated by considering the elementary examples of a simply supported column and a two-bar truss. The traditional approach to least weight design of aircraft structures is stated to be formulating

the optimization problem in terms of equations, and a variation is the reduction of the objective function to one of a single variable. Terminology used in mathematical programming is defined and the main features in applying the techniques to structural design are outlined. Mathematical programming techniques applied to materials selection is usually characterized by a discrete set of available materials, even for composite materials.

N.E.N.

**N71-20139#** Advisory Group for Aerospace Research and Development, Paris (France).

**OPTIMIZATION UNDER AEROELASTIC CONSTRAINTS**

H. Ashley, S. C. McIntosh, Jr., and W. H. Weatherhill *In its* Structural Design Appl. of Mathematical Programming Tech. Feb. 1971 p 144-173 refs Sponsored by NASA and the AF

(NASA-CR-117198) Avail: NTIS CSCL 20K

Two major lines of development in the optimization of aeroelastic constraints for high performance aircraft design are discussed. The optimization of problems with one-dimensional space variable can be identified as a variational problem and reduced to systems of first-order ordinary differential equations. Discretization by assumed-mode and finite element methods are also described, and the control variables are replaced with a finite vector of  $n$  adjustable element properties. Minimization of the chosen merit function amounts to a search of  $n$ -vectorspace. Mathematical discussions of examples are given for each method, and the importance of each method in future development is indicated.

N.E.N.

**N71-20140#** Advisory Group for Aerospace Research and Development, Paris (France).

**OPTIMIZATION TECHNIQUES IN AIRCRAFT  
CONFIGURATION DESIGN**

B. Silver and H. Ashley *In its* Structural Design Appl. of Mathematical Programming Tech. Feb. 1971 p 174-194 refs

Avail: NTIS

Parametric analysis and automated search methods for preliminary design optimization are compared, and methods of optimization that go beyond parametric analysis are investigated. Indirect methods, such as the calculus of variations, are mentioned. Direct methods of optimization are discussed including selection of design variables, constraint formulation, methods with and without derivatives, one dimensional search methods, and convergence criteria. The indirect methods solve auxiliary problems, while the direct methods adopt a hill-climbing strategy on the objective function directly. Operational results of direct search methods are given, and the field of man-computer interactive design is briefly described.

N.E.N.

**N71-20156#** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**INVESTIGATION OF FLOW FIELD DEVELOPMENT FOR A  
SERIES OF SONIC BOOM WIND TUNNEL MODELS**

Harry L. Runyan, Herbert R. Henderson, Odell A. Morris, and Christine G. Pusey Washington Mar. 1971 21 p refs  
(NASA-TN-D-6143; L-7236) Avail: NTIS CSCL 20D

A wind tunnel experiment has been conducted at a Mach number of 2.7 to study the growth of the pressure field as a function of distance from sonic boom models. Six models were tested: two delta planforms and four rectangular planforms including one model with side plates. The measured sonic boom pressure signatures are compared with calculated signatures based on theories for two- and three-dimensional flows.

Author

**N71-20157#** Aircraft Research Association, Ltd., Bedford (England).

**POSSIBILITIES FOR SCALE EFFECT ON SWEEPED WINGS AT HIGH SUBSONIC SPEEDS. RECENT EVIDENCE FROM PRESSURE PLOTTING TESTS**

A. B. Haines Feb. 1971 36 p refs Presented at AGARD Fluid Dyn. Panel Specialists' Meeting, Goettingen, Germany, 26 - 28 Apr. 1971

(ARA-18) Avail: NTIS

The possibilities for scale effect on swept wings under supercritical flow conditions at high subsonic speeds are discussed on the basis of evidence from pressure plotting tests on a variety of wings. For the Super VC 10, comparison of pressure distributions measured in flight, and in model tests at  $R = 5.4$  million shows some scale effect but it is not dramatic, largely because there is no incipient rear separation tendency in the tunnel tests. For other designs however, the scale effect could be much greater: it is shown that the underfixing technique has limitations when applied to a sweptback wing. Examples are included where the flow patterns are very complex with many interacting features, in such cases, it is often difficult even to forecast whether the scale effect is favorable or unfavorable.

Author

**N71-20158\*#** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**EXPERIMENTAL INVESTIGATION OF THE DIRECTIONAL CONTROL CAPABILITY OF 18 x 5.5, TYPE 7, AIRCRAFT TIRES ON WET SURFACES**

Thomas A Byrdsong Washington Mar. 1971 19 p refs (NASA-TN-D-6202; L-7547) Avail: NTIS CSCL01A

An experimental investigation was made to evaluate the free-rolling cornering capability of a high-speed aircraft nose-wheel tire. Data were obtained for several 18 x 5.5, type 7 tires with three tread designs (three-grooved, six-grooved, and dimple) at wheel yaw angles up to 30 deg and ground speeds up to 110 knots on various wet and flooded test surfaces. The results show a characteristic variation of cornering capability with wheel yaw angle and suggest a maximum cornering capability at an angle of approximately 10 deg. The surface texture, wetness condition, and ground speed are shown to have a pronounced effect on the cornering capability of the test tires. The results also show that the tires with three- and six-grooved-tread designs developed cornering capability that was comparable to and significantly greater than that of the dimple-tread tires.

Author

**N71-20180#** Douglas Aircraft Co., Inc., Long Beach, Calif.  
**FORMAT-FORTRAN MATRIX ABSTRACTION TECHNIQUE. VOLUME 2: DESCRIPTION OF DIGITAL COMPUTER PROGRAM, EXTENDED, SUPPLEMENT 3 Final Report, 1 Jul. 1968 - 30 Apr. 1970**

W. J. Lackey and S. H. Miyawaki Wright-Patterson AFB, Ohio AFFDL Aug. 1970 161 p refs (Contract F33615-68-C-1633)

(AD-715982; DAC-33569-Vol-2-Suppl-3;

AFFDL-TR-66-207-Vol-2-Suppl-3) Avail: NTIS CSCL20/11

The FORMAT System has been updated by the incorporation of additional basic capability and the refinement of existing capability. A simpler mode of updating case data and extended force method matrix generation capability has been incorporated in Phase I of the system. A refined Structure Cutter module, capabilities for matrix partitioning and instruction looping, and an additional eigenvalue/eigenvector extraction module have been incorporated in Phase II. Finally the limitations which existed in the matrix plotting capability in Phase III have been eliminated. Programming documentation for the extended capability of Phase II of the FORMAT System is presented in the report.

Author (GRA)

**N71-20181\*#** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**SUPERSONIC AERODYNAMIC CHARACTERISTICS OF A ROCKET-VEHICLE MODEL WITH LOW-ASPECT-RATIO WING AND TAIL SURFACES**

Ernauld B. Graves Washington Mar. 1971 52 p refs (NASA-TM-X-2159; L-7339) Avail: NTIS CSCL20D

A wind tunnel investigation was conducted to determine the static aerodynamic characteristics of a rocket vehicle model with low aspect ratio cruciform wing and tail surfaces at Mach numbers from 1.50 to 4.64. The results indicate that the model with the wings in the aft position provided less variation in the center of pressure location with Mach number than the model with the wings in the forward position. For both wing positions, however, the model exhibited non-linear pitching moment characteristics in the lower Mach number and angle of attack ranges. Little or no induced roll or yaw was indicated over the ranges of angle of attack and Mach number.

Author

**N71-20182\*#** General Motors Corp., Indianapolis, Ind. Allison Div.

**EXPERIMENTAL INVESTIGATION OF ADVANCED CONCEPTS TO INCREASE TURBINE BLADE LOADING. VOLUME 7: PERFORMANCE EVALUATION OF MODIFIED JET-FLAP ROTOR BLADE**

H. G. Lueders Washington NASA Mar. 1971 31 p refs (Contract NAS3-7902)

(NASA-CR-1759; EDR-4909-Vol-7) Avail: NTIS CSCL20D

The performance of a single stage turbine with a modified jet flat rotor blade was investigated over a range of secondary airflows and expansion ratios while operating at design equivalent speed. The blade modification consisted of reducing the axial chord at all radii 0.276 inch by removing metal from the leading edge portion of the original blade. The nose of the blade was recontoured to blend into the suction and pressure surfaces. The leading edge portion of the original blade had very little turning and it was therefore anticipated that the additional loading to the modified blade would be small. The results of the investigation are compared to the performance of the original jet flap blade. Both rotors were tested with the same stator.

Auth

**N71-20183\*#** Southampton Univ. (England). Inst. of Sound and Vibration Research.

**THE TRANSMISSION OF SONIC BOOM SIGNALS INTO ROOMS THROUGH OPEN WINDOWS. PART 1: THE STEADY STATE SOLUTION**

P. G. Vaidya [1970] 35 p refs (Grant NGR-52-025-003)

(NASA-CR-111786) Avail: NTIS CSCL20A

As a first step in calculating transient pressure time-histories in rooms due to sonic booms, a solution is sought for the pressure field generated inside a room due to an incoming harmonic wave, incident onto a window. The basic problems of sound radiation and diffraction are first discussed. These are used to obtain a solution in the case of a room with hard walls and normal incidence, first by viewing the room as a terminated duct, and later by the Green's function method. The concept of the mode excitation distribution function is used to match the boundary conditions. This concept has been extended for oblique incidence. General properties of the distribution function were derived.

Author

**N71-20191\*#** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**A WIND TUNNEL INVESTIGATION OF HELICOPTER DIRECTIONAL CONTROL IN REARWARD FLIGHT IN GROUND EFFECT**

## N71-20195

Robert J. Huston and Charles E. K. Morris, Jr. Washington Mar. 1971 40 p refs  
(NASA-TN-D-6118; L-7432) Avail: NTIS CSCL 14B

An investigation was conducted in the Langley full-scale tunnel to study the aerodynamics that produce directional-control problems for a helicopter with a tail rotor in low-speed rearward flight in ground effect. A helicopter model mounted close to the tunnel floor was tested in tail winds from 0 to 25 knots. Author

**N71-20195\*** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

### **A STUDY OF THE MIXING OF HYDROGEN INJECTED NORMAL TO A SUPERSONIC AIRSTREAM**

R. Clayton Rogers Washington Mar. 1971 54 p refs  
(NASA-TN-D-6114; L-7386) Avail: NTIS CSCL 20D

The effects of the ratio of jet dynamic pressure to free-stream dynamic pressure, in the range of 0.5 to 1.5, on the penetration and mixing of a sonic hydrogen jet injected normal to a Mach 4 airstream were determined. Free-stream conditions consisted of a stagnation temperature of 300 K and stagnation pressures of 13.6 and 20.4 atmospheres. Turbulent boundary-layer thickness at the injection station was 2.70 injector diameters. Measurements of hydrogen volume fraction and pitot pressure were made at downstream stations between 7 and 200 injector diameters. It was found that the penetration trajectory was proportional to the 0.3 power of the dynamic-pressure ratio and the decay of the maximum concentration (to values of 0.1) was inversely proportional to the square root of the downstream distance. Nondimensional concentration profiles for the vertical surveys were approximated by Gaussian-type functions and showed similarity at stations equal to or greater than 60 injector diameters. Author

**N71-20196\*** National Research Council of Canada, Ottawa (Ontario) Div. of Mechanical Engineering.

### **CIRCULATION CONTROL BY SLOT SUCTION ON A CIRCULAR CYLINDER. MEASURED FORCE CHARACTERISTICS OF A SMOOTH DOUBLE SLOTTED CYLINDER**

R. A. Tyler and R. G. Williamson Jul. 1970 30 p refs  
(NRC-11714; LR-539) Avail: NTIS

Force characteristics are presented for a uniformly smooth circular cylinder, equipped with one and two spanwise sharp-edged slots (slot separation 60 deg.  $s/d = 0.05$ ). Suction coefficients from zero to about 1.0 (per slot) were applied over the complete incidence range at low mainstream Mach number ( $M_\infty = 0.15$ ,  $R_{sub} = 100,000$  to 700,000). The single slot data are compared with earlier results for a relatively rough cylinder. The two-slot data are examined in some detail for the zero suction rate over the complete incidence range, and the full test range of suction coefficient at the particular incidence involving rear symmetry of slot position. Author

**N71-20248\*** Boeing Co., Seattle, Wash. Aerospace Group.  
**PREDICTION OF MECHANICAL EROSION OF CHARRING ABLATORS**

Lauri H. Hillberg In NBS Space Simulation Oct. 1970 p 837 851 refs  
Avail: SOD \$5.25

A simple method has been developed for predicting the mechanical erosion of charring ablaters exposed to an aerodynamic environment. The method requires the knowledge of two variables: the aerodynamic shear stress at the ablating surface and the surface temperature. Test data are used to obtain two empirical constants necessary for correlating the erosion recession rate in terms of these two variables. The empirical constants have been

determined for phenolic cork, phenolic carbon, epoxy-novolac, and high density silicone rubber. Author

**N71-20251\*** Air Force Systems Command, Wright-Patterson AFB, Ohio. Flight Dynamics Lab.

### **OPERATING CHARACTERISTICS OF THE AIR FORCE FLIGHT DYNAMICS LABORATORY REENTRY NOSE TIP (RENT) FACILITY**

J. C. Beachler In NBS Space Simulation Oct. 1970 p 893-904 refs

Avail: SOD \$5.25

Reentry missile nose tip development requires ground test facilities capable of simultaneously producing extreme pressures and heat transfer rates. A Reentry Nose Tip (RENT) Facility was developed to produce this high pressure hyperthermal environment. The present and planned capability of this facility is described and typical pressure and heat transfer profiles of the test jet are shown. Author

**N71-20256\*** Scripta Technica, Inc., Washington, D.C.

### **SECOND APPROXIMATION IN THE PROBLEM OF STRONG VISCOUS INTERACTION ON THIN THREE DIMENSIONAL BODIES [VTOROE PRIBIZHENIE V ZADACHE O SILNOM VIAZKOM VZAIMODEISTVII NA TONKIKH PROSTRANSTVENNYKH TELAKH]**

V. V. Mikhailov NASA Mar. 1971 11 p refs Transl. into ENGLISH from Izv. Akad. Nauk SSSR, Mekh. Zhidk. Gaza (Moscow), Sep.-Oct. 1970 p 107-113  
(Contract NASw-2036)

(NASA-TT-F-13538) Avail: NTIS CSCL 20D

A hypersonic perfect gas flow past a thin three dimensional body under conditions of strong viscous interaction is studied. Relations are derived which make it possible to reduce the problem of determining the aerodynamic characteristics of an axisymmetric body to a calculation of a flow past a certain equivalent body of revolution at zero angle of attack. A second approximation for the heat transfer and drag coefficients is obtained by the method of outer and inner coalescing asymptotic expansions. An estimate is made of the range of applicability and the accuracy of the asymptotic theory on the basis of a comparison with examples of exact numerical calculations. Author

**N71-20271\*** Bell Aerospace Co., Buffalo, N.Y.

### **AN ANALYSIS OF CORRELATING PARAMETERS RELATING TO HOT GAS INGESTION CHARACTERISTICS OF JET VTOL AIRCRAFT**

V. Krishnamoorthy Mar. 1971 46 p refs  
(Contract NAS1-10448)

(NASA-CR-111867) Avail: NTIS CSCL 01A

Inlet-air temperature rise data obtained from previous tests on two small-scale configurations of a jet VTOL fighter-type model over a range of exhaust pressure ratios, exhaust gas temperatures and surface wind velocities, was analyzed for correlation with several correlating parameters. The correlating parameters are used to predict the large-scale model inlet temperature rise. The large and small-scale results are compared. Author

**N71-20288\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

### **DESIGN AND PERFORMANCE OF A 0.9 HUB-TIP-RATIO AXIAL FLOW PUMP ROTOR WITH A BLADE-TIP DIFFUSION FACTOR OF 0.63**

Donald C. Urasek Washington Mar. 1971 34 p refs  
(NASA-TM-X-2235; E-5765) Avail: NTIS CSCL 20D

A 9-inch diameter axial flow rotor with a 0.9 hub-tip radius ratio, a design flow coefficient of 0.70, and a blade tip diffusion factor of 0.63 was tested in cold water under both cavitating and noncavitating conditions. Radial surveys of the flow conditions at the blade inlet and outlet were made. At design flow, the rotor produced an overall head-rise coefficient of 0.537 with an overall efficiency of 92.0 percent. The efficiency remained high over the entire flow range.

Author

**N71-20291\***# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FULL SCALE TESTS OF A SHORT LENGTH, DOUBLE ANNULAR RAM INDUCTION TURBOJET COMBUSTOR FOR SUPERSONIC FLIGHT**

Porter J. Perkins, Donald F. Schultz, and Jerrold D. Wear. Washington Mar. 1971 41 p refs

(NASA-TN-D-6254; E-5899) Avail: NTIS CSCL 21E

A 40-in. diameter combustor 20.25 in. in length gave performance equalling or exceeding that of a similar combustor 50 percent longer. Tests were with inlet-air at 1150 F and 90 psia at 1050 F and 60 psia, and at 600 F (589 K) and 90 psia, with 2200 F (1478 K) exit temperatures. Combustion efficiency was 100 percent, exit temperature profiles were good, and no visible smoke was measured. At cruise and takeoff, pattern factors were 0.20 and 0.25, and pressure loss 8.4 percent and 6.2 percent, respectively. Blowout limits, altitude relight, and response to rapid increase in fuel flow were measured over a wide operating range. Durability was satisfactory for 100 hr although some metal burning occurred at the 1150 F inlet temperature.

Author

**N71-20292\***# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

**UTILIZATION OF A FIXED BASE SIMULATOR TO STUDY THE STALL AND SPIN CHARACTERISTICS OF FIGHTER AIRPLANES**

Frederick L. Moore, Ernie L. Anglin, Mary S. Adams, Perry L. Deal, and Lee H. Person, Jr. Washington Mar. 1971 35 p refs

(NASA-TN-D-6117; L-7420) Avail: NTIS CSCL 01A

An investigation was conducted to determine the feasibility of using a fixed-base simulator for studies of the stall and spin characteristics of fighter airplanes. The simulator equipment consisted of a fixed-base cockpit with limited physical cues, including a visual display containing a target airplane for a realistic tracking task. The project was conducted as a real-time digital simulation with six-degree-of-freedom nonlinear equations of motion in which aerodynamic input data for two representative fighter configurations were used. One configuration was included to document its stall characteristics, whereas the spin and recovery characteristics of the other configuration were studied. The results of the study indicated that the fixed-base simulation technique could be employed for studying the stall and spin characteristics of an airplane.

Author

**N71-20305\***# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.

**FIXED-BASE SIMULATION EVALUATION OF VARIOUS LOW-VISIBILITY LANDING SYSTEMS FOR HELICOPTERS**

Paul S. Rempfer, Lloyd E. Stevenson, and Joseph S. Kozioł, Jr. Washington Apr. 1971 119 p refs

(NASA-TN-D-5913; C-119) Avail: NTIS CSCL 01A

A fixed-base simulation evaluation of various low-visibility landing systems for helicopters has been made. The low-visibility mission consisted of a straight-in glide slope and localizer approach with a flare and deceleration maneuver at the end. The landing systems consisted of a fully automatic system and six manual systems. The manual systems consisted of three flight control

modes each being flown with a flight director indicator and then with raw data displays. The three flight control modes were an attitude command mode with an unaugmented vertical axis, an attitude command mode with rate of descent command mode. The landing systems and the helicopter were simulated on a hybrid computer. The landing systems were all digital. A series of six subjects consisting of two engineers and four instrument-rated pilots flew each of the modes for the landing mission. Performance data were recorded by the digital computer and analog recorders. The relative performances of the modes are presented.

Author

**N71-20330#** Curtiss-Wright Corp., Wood-Ridge, N.J.

**GAS TURBINE COMBUSTION APPARATUS Patent**

Ralph J. Sneed, inventor (to NASA) Issued 18 Mar. 1969 (Filed 23 Jun. 1965) 11 p. Cl. 60-39.36, Int. Cl. F02g1/00, 3/00; Int. Cl. F02c3/00 Sponsored by NASA

(NASA-Case-XLE-10347-1; US Patent-3,433,015;

US-Patent-Appl-SN-466390) Avail: US Patent Office CSCL 21E

The design and characteristics of a combustion apparatus for a gas turbine engine are presented. The apparatus consists of a gas turbine unit in which the turbine nozzle guide vanes are used to introduce substantially all of the diluent air into the combustion gases. Mixing of the diluent air with the combustion gases produces a uniform temperature of the resulting gases both circumferentially and radially thus avoiding regions of excessive temperature in the combustion gases.

Official Gazette of the U.S. Patent Office

**N71-20334#** Comision Nacional de Investigaciones Espaciales. Buenos Aires (Argentina).

**AUTOMATIC FLIGHT CONTROL SYSTEMS [SISTEMAS AUTOMATICOS DE CONTROL DE VUELO]**

T. Hajduk 1969 33 p In SPANISH /ts Informe de Contrato No. 9

Avail: NTIS

The dynamic response of a vehicle and its automatic flight control system is analyzed for four distinct types of systems. The system types are: (1) use of an activating signal to realign the control surfaces; (2) use of an error in position for the basic correction signal; (3) use of a signal derived from the angular velocity of the vehicle; and (4) use of angular velocity of the displacement of the control surfaces for the correction signal.

Transl. by F.O.S.

**N71-20347#** National Aerospace Lab., Tokyo (Japan).

**INVESTIGATION OF COMBUSTION PERFORMANCE OF TURBOJET COMBUSTOR**

Teikichi Otsuka, Shoji Horiuchi, and Kokichi Homma 1970 37 p refs In JAPANESE; ENGLISH summary

(NAL-TR-204) Avail: NTIS

Combustion performances of turbojet combustor models were studied varying inlet-air pressure, temperature and velocity independently. Characteristics of the combustion performance such as combustion efficiency and temperature distribution in the combustion zone were obtained for different air-entry hole arrangements and fuel nozzles of the can-type combustors.

Author

**N71-20369#** Dunlap and Associates, Inc., Santa Monica, Calif.

**THE INFLUENCE OF ENVIRONMENTAL FACTORS IN AIRCRAFT CARRIER LANDINGS AND ACCIDENTS**

Clyde A. Brictson /in AGARD Adaptation and Acclimatization in Aerospace Med. Mar. 1971 7 p refs

Avail: NTIS

An analysis of carrier landing accidents during a five year period (1965-1969) showed that environmental causal factors contributed to 27% of all jet landing accidents. Pitching deck was the most frequently cited environmental causal factor and was cited in 15% of the landing accidents. The F4 aircraft had the highest percentage of environment related mishaps (36%), half of which were pitching deck accidents (18%). Furthermore, pitching deck conditions were found to be related to two accident types, hard landings and undershoots, which accounted for 93% of all landing accidents. Pilot/aircraft height tracking responses under different levels of deck pitch were analyzed and results indicate that deck motion in excess of four feet may result in a 180 deg phase relation between deck pitch and pilot height tracking for certain aircraft. Synchronized records of deck motion and pilot aircraft height tracking during final approach to night carrier landing deck chasing phenomenon and provide graphic evidence of the consequences of 180 deg phase lags, especially for high accident risk aircraft. Author

**N71-20392\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**DESIGN STUDY OF SHAFT FACE SEAL WITH SELF-ACTING LIFT AUGMENTATION. 3: MECHANICAL COMPONENTS**

Lawrence P. Ludwig and Robert L. Johnson. Washington. Mar. 1971. 19 p. refs.  
(NASA-TN-D-6164; E-5980) Avail: NTIS CSCL 11A

A main shaft face seal with self-acting geometry was designed for gas turbine engine applications. The seal design goal was to minimize thermal deformation; this was achieved, in part, through use of thermal shielding and through use of a molybdenum alloy which has high thermal conductivity and low thermal expansion. Also, the seal seat was structurally isolated from the shaft by a radial spacer which mitigated the thermal movements of the shaft. Further, axial clamping of the seat through a bellows spacer limited the axial clamping force and thus minimized clamping deformation. Wear measurements after 120 hours of operation under simulated engine conditions of a 200-psi (138 N/sq cm) pressure differential, a 400-ft/sec (122-m/sec) sliding speed, and a 1000 F (811 K) sealed gas temperature showed that thermal deformation was not excessive. Author

**N71-20398\*** Wyoming Univ., Laramie. Dept. of Physics.

**AN AIRCRAFT BORNE DUST PARTICLE COUNTER AND ITS APPLICATIONS TO THE STUDY OF CLEAR AIR TURBULENCE**

James M. Rosen and Robert A. Sadler. [1970] 16 p. refs.  
(Contract NAS1-9592)  
(NASA-CR-111864) Avail: NTIS CSCL 04B

The instrumentation required for the detailed mapping of aerosol concentration in a region of clear air turbulence is described. The stages presented are the initial development of an airborne aerosol detector, environmental testing, and field testing. The results indicate that a qualitative measurement of atmospheric aerosols can be made by an airborne particle counter. F O S

**N71-20419\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**SMOKE EVALUATION OF A MODIFIED J-57 COMBUSTOR**

Jack Grobman and Leonidas C. Papathakos. Washington. Mar. 1971. 38 p. refs.  
(NASA-TM-X-2236; E-6005) Avail: NTIS CSCL 21E

An experimental investigation was conducted to reduce smoke emission from a J-57 turbojet engine burning ASTM A-1 fuel by making modifications to the primary zone of the combustor.

Tests were performed with a single J-57 combustor liner that was installed in a 12-inch-diameter pipe. Mixing and percentage airflow in the primary zone were increased by varying the geometry of combustor dome and liner air-entry openings. The final modification reduced the smoke number from 64 to 24 at simulated takeoff conditions (combustor inlet total pressure, 12.3 atm). This was accompanied by a significant reduction in altitude relight capability. Author

**N71-20420\*** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**SUMMARY OF COLD-AIR TESTS OF A SINGLE-STAGE TURBINE WITH VARIOUS STATOR COOLING TECHNIQUES**

Thomas P. Moffitt, Herman W. Prust, Jr., Edward M. Szanca, and Harold J. Schum. [1971] 22 p. refs. Presented at the 16th Ann. Intern. Gas Turbine Conf. and Prod. Show, Houston, Tex., 28 Mar. - 1 Apr. 1971; sponsored by the Am. Soc. of Mech. Engr. (NASA-TM-X-52968) Avail: NTIS CSCL 21E

The results of a series of cold-air tests of the aerodynamic effects of coolant on turbine performance are presented. Annular stator exit surveys and single-stage tests were made of a 30-inch diameter turbine using three simulated coolant types of stator blading. The first ejected coolant into the mainstream through a slot in the blade trailing edge. The other two were of the porous skin type, one utilizing a self-supporting shell with discrete holes for variable porosity, and the other a wire mesh skin wrapped around an internal support strut with individual metering orifices and supply passages. Results are presented in terms of stator exit wake traces, stator efficiencies, stage efficiencies, and rotor efficiencies. Author

**N71-20421\*** Lockheed-California Co., Burbank.

**RESEARCH PROGRAM TO DETERMINE ROTOR RESPONSE CHARACTERISTICS AT HIGH ADVANCE RATIOS. Final Report**

W. A. Kuczynski and G. J. Sissingh. Feb. 1971. 220 p. refs. Sponsored in part by Army  
(Contract NAS2-5419)  
(NASA-CR-114290; LR-24122) Avail: NTIS CSCL 01A

The stability and response characteristics of directly controlled rigid rotors at high advance ratios were determined experimentally. The applicability of an existing mathematical model was evaluated by correlation with the test results. Provisions were made in the design of the rotor to vary the blade Lock number and the first flapping mode frequency. The blade Lock number was changed by adding weight at the tip of each blade. The flapping frequency was varied in two ways: by changing the stiffness of an inboard section of the blade (flapping flexure) and by changing the rotor speed. For each blade, one tip weight and two flexures were available which yielded four basic rotor configurations. Each basic configuration was tested at various rotational speeds. Eighteen discreet combinations of blade Lock number and flapping frequency were investigated. Nominal blade Lock number values were 5.0 and 3.0 and flapping frequency ranged from 1.14 to 2.39. Response data were taken at advance ratios up to 1.75 (including hover). Rotor derivatives with respect to four excitations were obtained, including collective pitch, longitudinal cyclic pitch, lateral cyclic pitch, and rotor shaft angle of attack. Author

**N71-20429\*** Hughes Research Labs., Malibu, Calif.

**THRUST DYNAMOMETER Patent**

Siegfried Hansen, inventor (to NASA). Issued 26 Aug. 1969 (Filed 10 Oct. 1967). 4 p. Cl. 73-117.4; Int. Cl. G0115/12. Sponsored by NASA.

(NASA-Case-XLE-05260; US-Patent-3,463,001;

US-Patent-Appl-SN-674355) Avail: US Patent Office CSCL 14B

A dynamometer for measuring the thrust of jet and rocket

engines is described. The thrust stand has a movable engine mounting platform supported at three points above a fixed platform by legs having pivotal ends. Counterweights are located below the platform and connected through rigid lever arms to the legs. Displacement of the platform along the direction of the thrust axis of the engine provides measurement of the thrust.

Official Gazette of the U.S. Patent Office

**N71-20505#** Bureau of Mines, Bartlesville, Okla.

**RADIOTRACER STUDY OF TURBINE AIRCRAFT FUEL STABILITY**

M. L. Whisman, F. O. Cotton, J. W. Goetzinger, and C. C. Ward  
Mar. 1971 34 p refs

(BMRI-7493) Avail: Issuing Activity

A radiotracer method for detecting the contribution of selected components and additives to thermally induce deposits of turbine aircraft fuels is discussed. Fuels were examined before and after 52 weeks of storage at 130 F. Of particular concern was the influence of aromatic hydrocarbon fuel constituents on thermal-stability quality of jet fuels during storage. A microfuel coker test apparatus was used to thermally stress the test fuels and blends, and the resultant contribution to deposits of selected fuel components, labeled with carbon-14, was determined by radioactive-counting techniques.

Author

**N71-20523\*#** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

**EFFECTS OF SURFACE CATALYSIS ON HEAT TRANSFER TO SHUTTLE ORBITERS**

Howard A. Stine 15 Mar. 1971 21 p refs

(NASA-TM-X-62016) Avail: NTIS CSCL 20M

The aerothermodynamic environment generated during much of the shuttle orbiter's entry flight consists of a flow of atoms and molecules. Oxygen is completely atomic and nitrogen is partly atomic and partly molecular. Two kinds of interactions of atoms with the shuttle surface are reviewed. First, the catalytic efficiency of the surface can change the incident heat transfer rate by factors of from two to three, depending upon whether the surface is chemically inert or chemically active, over the enthalpy range of peak heating. A corresponding surface radiation equilibrium temperature change of about 240 deg is calculated to be possible. Second, although information is scarce, indications are that oxidation rates of metals under attack by oxygen atoms can be one to two orders of magnitude greater than those corresponding to attack by oxygen molecules. Substantial improvement in shuttle operational capability, survivability, and longevity evidently can accrue if interaction of atomic oxygen with the shuttle surface can be suppressed.

Author

**N71-20531\*#** Techtran Corp., Glen Burnie, Md.

**COMBUSTION OF MAGNESIUM PARTICLES IN RAREFIED AIR [GORENIYE CHASTITS MAGNIYA V RAZREZHENNOM VOZDUKHE]**

V. A. Fedoseyev et al Washington NASA Mar. 1971 4 p refs Transl. into ENGLISH from Fiz. Aerodispersnykh Sistem (USSR), no. 2, 1970 p 98-101

(Contract NASw-2037)

(NASA-TT-F-13503) Avail: NTIS CSCL 21B

The results are evaluated of an experimental study of the combustion of large particles of magnesium during a change in the pressure of the ambient medium within the range from 100 to 760 mm Hg. It is found that the combustion time of a magnesium particle during an increase in the external pressure does not decrease monotonically, but passes through a maximum at pressures of the order of 400 mm Hg. Data concerning the length of the particle flame are obtained.

Author

**N71-20533\*#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**CONVERSION OF AN EXPERIMENTAL TURBOJET COMBUSTOR FROM ASTM A-1 FUEL NATURAL GAS FUEL**

Francis M. Humenik Washington Mar. 1971 33 p refs

(NASA-TM-X-2241; E-6031) Avail: NTIS CSCL 20M

A side-entry turbojet combustor previously developed with ASTM A-1 fuel was redesigned to use natural gas fuel. The rectangular test section simulated a segment of an annular turbojet combustor. Five combustor liner configurations and two fuel nozzle geometries were evaluated. Natural gas fuel temperatures ranging from -259 to 1200 F were investigated. The test conditions were as follows: nominally atmospheric inlet pressure; inlet air temperature to 600 F; and diffuser inlet Mach numbers of 0.24, 0.30, and 0.37 corresponding to nominal reference velocities of 77, 100, and 120 ft/sec, respectively. The combustor configurations were designed to achieve combustor exit temperatures combustion efficiency and desirable radial exit-temperature profiles having low pattern factors were achieved with only minor combustor modifications. Ignition was readily obtained with natural gas temperatures of -235 F.

Author

**N71-20539#** Illinois Univ., Urbana.

**HEAT TRANSFER IN RESONANT CAVITIES SPANNED BY LOW SPEED, TURBULENT, SHEAR LAYERS**

D. L. Fenton and R. A. White [1970] 13 p refs

(Grant NSF GK-2053)

Avail: Issuing Activity

The effect of cavity resonance on the dynamic and thermal characteristics of resonant cavities at low speeds was measured in a free-jet wind tunnel. A model of heat transfer in resonant cavities spanned by low speed, turbulent, shear layers was used to correlate both resonant and nonresonant results. The effect of resonance at low speeds where the pressure oscillations were weak in relation to high speed results did not produce major flow changes. It was concluded that the cavity thermal characteristics could be satisfactorily predicted by the nonresonant theory since the resonance effects were immeasurable.

J.M.

**N71-20540#** Illinois Univ., Urbana.

**SOME RESULTS ON THE HEAT TRANSFER WITHIN RESONANT CAVITIES AT SUBSONIC AND SUPERSONIC MACH NUMBERS**

Robert A. White [1970] 31 p refs

(Grant NSF GK-2053)

Avail: Issuing Activity

The heat transfer within two cavities ( $L/D = 1.25$  and  $2.0$ ) exhibiting self-induced pressure oscillations (commonly referred to as resonance) is discussed. The tests were conducted with free stream Mach numbers between 0.35 and 1.5 with corresponding unit Reynolds numbers of 3,300,000/ft to 4,100,000/ft. The approaching boundary layer and shear layer over the cavities were turbulent at all times. The pattern for the heat transfer coefficient distribution over the cavity walls was in good agreement with that found by other investigators. The effect of the self-induced pressure oscillations, however, was found to cause large changes in the level of the heat transfer, with low values occurring at the distinctive peaks of the pressure oscillations. The ratio of the integrated heat transfer within the cavity to the heat transfer from a flat plate with area equal to the area of the cavity opening was found to vary from 1.10 to 0.40, depending on Mach number and cavity resonance conditions.

Author

**N71-20548#** Loughborough Univ. of Technology (England). Dept. of Transport Technology.

**DEPARTMENT OF TRANSPORT TECHNOLOGY Research**

**N71-20570**

**Report, 1970**

K. L. C. Legg and D. J. Johns, eds. 1970 121 p refs

Avail: NTIS

Research efforts reported are concerned with: (1) aircraft and missiles; (2) automobiles and heavy road vehicles; (3) surface trains and tube transport vehicles; and (4) marine and tracked hovercrafts. Other topics include problems of industrial aerodynamics relevant to civil engineering structures and their optimization and control. G.G.

**N71-20570\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**ATTITUDE CONTROLS FOR VTOL AIRCRAFT Patent**

Frank A. Pauli, inventor (to NASA) Issued 14 Oct. 1969 (Filed 24 Jan. 1968) 7 p Cl. 244-76; Int. Cl. B64c13/50, 15/14

(NASA-Case-XAC-08972; US-Patent-3,472,470;

US-Patent-Appl-SN-700174) Avail: US Patent Office CSCL 01A

Attitude control for VTOL aircraft can be achieved by employing reaction nozzles displaced from various axes of the aircraft. The nozzles are arranged two sets with each set of nozzles being fed by a separate duct system selectively connected to a source of gas under pressure, preferably bled off from a jet engine. For control about each orthogonal axis, nozzles of the first set are controlled mechanically and nozzles of the second set are controlled electrically by servo motors. A valve is interposed between the supply duct and ducts feeding the separate systems and is movable into two positions to supply one or the other system exclusively of the other. Biasing means urges the valve into position for manual control and electrically operated means urges it into position for electrical control. Hence, the system is returned to manual control immediately at pilot option or by failure of the electrical system.

Official Gazette of the U.S. Patent Office

**N71-20617#** Systems Technology, Inc., Hawthorne, Calif.

**A PRACTICAL OPTIMIZATION DESIGN PROCEDURE FOR STABILITY AUGMENTATION Final Technical Report,**

Jan. - Nov. 1969

R. L. Stapleford, D. T. McRuer, L. G. Hofmann, and L. G. Teper Wright-Patterson AFB, Ohio AFFDL Oct. 1970 125 p refs (Contract F33615-69-C-1359)

(AD-717168; STI-TR-187-1; AFFDL-TR-70-11) Avail: NTIS CSCL 1/3

A systematic procedure for the design of aircraft stability augmentation systems is presented. The key features of this procedure are the selection of essential feedbacks from an examination of several handling quality metrics and the use of parameter optimization techniques to determine the numerical values of the SAS parameters. The optimization problem is structured to include both manual and SAS feedbacks. The cost function includes pilot tracking errors and SAS control deflections. A method of selecting the relative weighting is presented. The feasibility of this procedure is demonstrated by applying it to the longitudinal axis of the F-4 aircraft. Three widely different flight conditions are selected. For all three, the same SAS form (pitch rate and normal acceleration feedbacks to the elevator), the identical problem formulation, and the same method of selecting the cost function weights are used. The resulting systems are judged quite satisfactory and well within the short-period requirements of the current military handling qualities specification. Author (GRA)

**N71-20630\*#** Cornell Aeronautical Lab., Inc., Buffalo, N.Y.

**AN EXPERIMENTAL INVESTIGATION AND EVALUATION OF A DOPPLER RADAR TECHNIQUE FOR THE MEASUREMENT OF THE FLOW GENERATED BY WING TIP**

**VORTICES Final Summary Report**

William W. Joss, Hendrik W. Prinsen, and Calvin C. Easterbrook 20 Jan. 1971 55 p refs

(Contract NAS1-10290)

(NASA-CR-111877; CAL-AF-3015-C-1) Avail: NTIS CSCL 20P

Results are described of tests conducted to determine if radar reflective chaff injected at the wing tip of an aircraft would be ingested into the vortex structure and sufficiently distributed to allow velocity profiles to be measured by a Doppler radar. The results are presented in the form of flow field visualization results and an analysis of radar returns. The data show that individual chaff filaments dispensed at the wing tips of an Aztec aircraft are entrained by the wing tip vortices. An examination of the radar returns reveals the presence of large Doppler spreads in relatively small regions of the vortices. It was also found that a substantial percentage of the chaff had a tendency to form clumps which hampered the determination of the detailed velocity profiles.

Author

**N71-20666#** National Aviation Facilities Experimental Center, Atlantic City, N.J.

**VORLOC 2 FAR PART 171 COMPLIANCE TEST Final Report, Mar. Sep. 1970**

Frederick W. Marshall Apr. 1971 65 p

(FAA-RD-71-12; FAA-NA-71-5) Avail: NTIS

A low cost simplified directional approach system called VORLOC was developed. The equipment was examined by the Federal Aviation Administration as part of an effort to determine the acceptability of VORLOC 2 as a non-federal IFR aid for public use. This examination consisted of performing tests to gather data relative to the requirements of part 171, subpart F, of the Federal Aviation Regulations. Test data were also obtained on the effect of environmental factors on elements of the system. The tests are described and the resulting data are presented in graphs and tables. Author

**N71-20674\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

**A SUPERSONIC INLET-ENGINE CONTROL USING ENGINE SPEED AS A PRIMARY VARIABLE FOR CONTROLLING NORMAL SHOCK POSITION**

Francis J. Paulovich, George H. Neiner, and Ralph E. Hagedorn Washington Mar. 1971 43 p refs

(NASA-TN-D-6021; E-5492) Avail: NTIS CSCL 21A

A cross coupled inlet engine control system concept is presented for a supersonic propulsion system consisting of a mixed compression inlet and a turbojet engine. The control system employs manipulation of both bypass door flow area and engine speed to stabilize normal shock position in the inlet. Specifically, the case of slow-acting bypass doors used as a reset control where engine speed is the primary means of shock position control is described. Experimental results are presented showing performance of the control system with a NASA-designed inlet and a turbojet engine operating at Mach 2.5 in the Lewis 10- by 10-Foot Supersonic Wind Tunnel. Author

**N71-20685#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Abteilung Aerodynamik.

**A CRITICAL EXAMINATION OF THE EQUATION FOR THE DRAG OF THE KARMAN VORTEX STREET [KRITISCHE BETRACHTUNGEN DER FUER PERIODISCHE TOTWASSER GELTENDEN KARMANSCHEN WIDERSTANDSGLEICHUNG]**

M. Tanner Jun. 1970 23 p refs In GERMAN; ENGLISH summary

(DLR-FB-70-27; AVA-FB-7007) Avail: NTIS; ZLDI Munich: 6 DM

The periodic wake behind bluff bodies is examined with special regard to the Karman drag equation. The assumptions of the Karman equation are inspected under new points of view considering the effect of the steady part of the base flow on the drag. This gives a new estimate for the vortex strength. The differences existing between the drag measured directly and that derived from the Karman equation are explained. Author (ESRO)

**N71-20695#** California Univ., La Jolla. Dept. of the Aerospace and Mechanical Engineering Sciences.

**A KOITER-TYPE METHOD FOR FINITE ELEMENT ANALYSIS OF NONLINEAR STRUCTURAL BEHAVIOR. VOLUME 2: USER'S MANUAL FOR PROGRAM BEHAVE Final Report, 17 Oct. 1969 - 17 Oct. 1970**

R. T. Haftka, R. H. Mallett, and W. Nachbar Wright-Patterson AFB, Ohio AFFDL Nov. 1970 108 p

(Contract F33615-69-C-1899)

(AD-717181; AFFDL-TR-70-130-Vol-2) Avail: NTIS CSCL 20/11

The report contains the description of the FORTRAN language program BEHAVE that was used to obtain the numerical results for the example problems that are presented and discussed in Volume I. Program BEHAVE is designed for the analysis of the structural behavior of rigidly jointed planar frames. The finite element used for the analysis is the stability element described in Section IV of Volume I. BEHAVE can perform a linear stability analysis, a Modified Structure method analysis, a direct nonlinear analysis, and combination of the above analyses. This volume consists of three parts: a Users guide; a programmers manual; and a listing of the program and subroutines. Author (GRA)

**N71-20702#** Dynamic Science, Irvine, Calif.

**FLIGHT VIBRATIONAL AND ENVIRONMENTAL EFFECTS ON FORMATION OF COMBUSTIBLE MIXTURES WITHIN AIRCRAFT FUEL TANKS Final Report, 23 Jun. 1969 - 31 Mar. 1970**

T. C. Kosvic, N. L. Helgeson, and B. P. Breen Sep. 1970 87 p refs

(Contract DAAJ02-69-C-0063)

(AD-875901; SN-162-F; USAAVLABS-TR-70-43) Avail: NTIS CSCL 21/2

The objective of the study was to determine fuel tank vapor space characteristics for a simulated helicopter fuel tank and to evaluate the potential hazard which exists. Fuel/air ratios were measured as a function of time and position within the ullage of the fuel tank for specified flight profiles. These results were compared to published flammability limits as a basis for assessing flight hazard potential. The flight profiles were simulated by withdrawing fuel at rated engine usage from a vibrating tank held at constant pressure and temperature. Parametric variations were made in fuel temperature 40 to 100 F, flight altitude 0 to 15,000 feet, vibration environment, and fuel properties Liquid JP-4 versus JP-4 emulsion EF 4-104 H. Another important variable not considered initially but which was uncovered during the course of this investigation was the effect that the rubberized tank liner could have on the measured fuel/air ratios. The extent of this effect was found to be related to fuel temperature and exposure time of the liner to the fuel. The experimental results showed those ranges of the test variables which had a significant effect on the measured fuel/air ratios. They also demonstrated that fuel/air mixture gradients do exist in fuel tanks under flight conditions. It was found that tanks which would be considered safe as determined by calculations for equilibrium conditions actually contain flammable regions, even for level flight. An analytical model for the ullage space was written which included transient fuel vapor diffusion and convection which was brought about by venting of the ullage.

(GRA)

**N71-20719\*#** Scientific Translation Service, Santa Barbara, Calif.

**CONTROL SYSTEMS FOR SINGLE-ROTOR HELICOPTERS**

I. S. Dmitriyev et al Washington NASA Mar. 1971 325 p refs Transl. into ENGLISH of the "Sistemy Upr. Odnovintovykh Vertoletov" Moscow, Mashinost., 1969 325 p

(Contract NASw-2035)

(NASA-TT-F-636) Avail: NTIS HC\$6.00/MF\$0.95 CSCL 01C

The theoretical foundations of helicopter stability, controllability, and maneuverability are discussed to the extent necessary for the design of control systems, with major attention being devoted to clarification of the physical aspects of the phenomena. Those characteristics of helicopter control systems which differentiate them from airplane control systems are examined. The optimal helicopter controllability characteristics, the rigid lifting rotor with control gyroscope, and the mathematical description of the pilot transfer functions in the closed loop helicopter control system are examined.

Author

**N71-20754#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**ESTIMATION OF STABILITY OF ELASTIC NONCIRCULAR CONICAL AND CYLINDRICAL ORTHOGONAL CASINGS**

Yu. P. Petrov 16 Oct. 1971 36 p refs Transl. into ENGLISH from Samoletost. Tekh. Vozdush. Flota (Kharkov), no. 15, 1968 p 75 89

(AD-717014; FTD-HC-23-460-70) Avail: NTIS CSCL 20/11

Noncircular conical and cylindrical shells, orthotropic and isotropic, are used in various branches of industrial construction: aircraft construction, ship construction, etc. The stability analysis of such shells, even in geometrically linear formulation, is a very complex problem. The solution of this problem with the aid of the presently known approximate analytic methods involves serious difficulties. It is probable that this is one of the reasons for the very small number of studies devoted to the stability of noncircular conical and cylindrical thin-wall shells. In the present paper this problem is solved by the differential-difference method, which is known in the literature as the method of straight lines or strip method.

Author (GRA)

**N71-20765#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**A DIGITAL COMPUTING DEVICE FOR AN INERTIAL NAVIGATION SYSTEM**

V. O. Storozhenko et al 28 Oct. 1970 10 p refs Transl. into ENGLISH from Dopov. Akad. Nauk Ukr. RSR, Ser. A, F.-T. M. N. (Kiev), v. 29, no. 9, 1967 p 827-829

(AD-717058; FTD-HC-23-1504-68) Avail: NTIS CSCL 9/2

The operation of a computer serving an inertial navigation system with stabilization in the horizontal plane requires the solution of a system of three nonlinear differential equations involving, as variables, the latitude and longitude of the moving object, and the angle which characterizes the position of the plane in the azimuth with respect to the geographical system of coordinates. Unfortunately, a computer designed to deal directly with these equations involves a number of technical difficulties leading to substantial errors. By introducing the Rodrigues-Hamilton parameters, the author reduces the computing function essentially to the solution of four linear differential equations equivalent to the original system. One apparent advantage of a computer so designed is that no shift to a second coordinate system is required in the case of navigation near the poles.

Author (GRA)

**N71-20766\*#** National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**EXPERIMENTAL INVESTIGATION OF THE EFFECT OF**

**SCREEN INDUCED TOTAL PRESSURE DISTRIBUTION ON TURBOJET STALL MARGIN**

James E. Calogeras, Charles M. Mehalic, and Paul L. Burstadt  
Washington Mar. 1971 55 p refs  
(NASA-TN-X-2239; E-5981) Avail: NTIS CSCL 21E

The effect of several circumferential, radial, and combined distortions on the stall margin of a J85-GE-12 turbojet engine was investigated. The compressor was found to have a critical angle of circumferential distortion equal to 60 deg. For both single and multiple circumferential distortions, loss in compressor pressure ratio at stall was correlated with a simple distortion index based on the lowest mean pressure in any 60 deg sector of the compressor face flow field. Hub radial distortion was found to affect the pumping capacity and pressure ratio of the compressor, but not stall margin; however, tip radial distortion did affect the stall margin. The circumferential component of a combined pattern was generally found to be the predominant factor affecting stall margin. Author

**N71-20768#** Rome Univ. (Italy). School of Aerospace Engineering.

**A CONTRIBUTION TO THE THEORY OF MULTIWEB WING STRUCTURES [CONTRIBUTO ALLA TEORIA DELLE STRUTTURE ALARI MULTILONGHERONE]**

Carlo Arduini and Giuliano Quozzo Jul. 1970 49 p refs In ITALIAN; ENGLISH summary *Its* ATTI del Centro Ric. Aerospaziali No. 29  
Avail: NTIS

The problem of the torsion of a multiweb wing structure is analyzed in the presence of stresses normal to the plane of the section. The transmission along the span of the stiffening effect produced by the base section being built in is studied in detail. The analysis has been performed on a discrete scheme as well as on a continuous scheme when the webs are in very large number. Author (ESRO)

**N71-20774#** Lincoln Lab., Mass. Inst. of Tech., Lexington  
**AIR TRAFFIC CONTROL Quarterly Technical Summary, 1 Aug. -31 Oct. 1970**

Herbert G. Weiss 15 Nov. 1970 22 p  
(Contract F19628-70-C-0230)

(AD-716816; ESD-TR-70-352) Avail: NTIS CSCL 17/7

The report covers the development of improved surveillance and communication subsystems to meet the demands of the automated NAS/ARTS Air Traffic Control system. Field measurements of the beacon interference environment were completed and studies to upgrade sensor efficiency were intensified. Effort toward the development of a discrete address interrogator with a data link was concentrated upon the core problem of designing the signaling waveforms for both up and down links of the system. Particular attention is being given to system performance in the interference and multipath environment, as well as to system and equipment compatibility with ATCRBS. The project to develop an airborne situation display of NAS/ARTS data has reached the stage for definition of an experimental system. The computer simulated cockpit display has evoked enthusiastic response from experienced pilots and traffic controllers. Preliminary work on the laser beam warning system for Logan Airport was completed with successful demonstration of the prototype hardware in the Laboratory. Author (GRA)

**N71-20806#** Air Force Cambridge Research Labs., Bedford, Mass.  
**FOG MODIFICATION BY USE OF HELICOPTERS**

Vernon G. Plank, Alfred A. Spatola, and James R. Hicks 28 Oct. 1970 164 p Prepared in cooperation with Atmospheric Sci. Lab. *Its* Environ. Res. Papers No. 335  
(AD-716818; AFCRL-70-0593; ECOM-5339) Avail: NTIS CSCL 4/2

Results of helicopter clearing experiments conducted at the Greenbrier Valley Airport, Lewisburg, West Virginia, during the period 7 to 29 Sep 1969, are presented and discussed. Thirty-five hover experiments and runway-clearing experiments were performed on 10 separate days with fog layers ranging from 125 to 525 ft in depth. The hover experiments, which were successful in virtually all cases, yielded clearings that varied from 400 to 2800 ft in length extent. The largest clearings occurred with the shallowest fog during tests conducted within one hour or so of the natural dissipation time of the fog. The runway-clearing experiments were successful in clearing the full 6000 ft extent of the runway on two occasions, were partially successful on four occasions and were unsuccessful on 12 occasions. Six helicopter landings were accomplished through artificially-created clearings. Quantitative information is described concerning the wake penetration distances of the helicopters, the steady-state clearing times, the total entrainment (mixing) values and the persistence times of the clearings following helicopter departure from the test sites. The temperature, humidity and wind speed values within the cleared zones are also given for certain of the experiments. Author (GRA)

**N71-20811#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**STABILITY OF DEFORMABLE SYSTEMS**

A. S. Volmir 22 Oct. 1970 113 p refs Transl. into ENGLISH from the book "Ustoichivost Deformiruemykh Sistem" Moscow, Nauka Press, 1967 113 p  
(AD-716938; FTD-HC-23-465-70) Avail: NTIS CSCL 20/11

The book deals with the stability of various structural elements, such as bars, plates, shells, beams and frame works of different shapes and designs. It outlines certain problems of hydroelasticity, and aeroelasticity. Criteria of dynamic stability, of initial imperfection, excentric compression, dynamic programming and uses of analog computers are discussed. Author (GRA)

**N71-20824#** Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio

**ACOUSTIC ENVIRONMENTS PRODUCED BY THE C-5A AIRCRAFT DURING GROUND OPERATIONS Final Report, Sep. 1969 - Apr. 1970**

John N. Cole and Robert G. Powell Oct. 1970 113 p refs  
(AD-716814; AMRL-TR-70-53) Avail: NTIS CSCL 20/1

Sound pressure levels produced by the C-5A aircraft during ground runup at idle, taxi, and takeoff power settings were measured at locations 200 meters radially distant from the aircraft. These data were used to compute power spectra, directivity indices, and contours of equal sound pressure level, A-weighted overall sound level, permissible exposure time, speech interference level and perceived noise level (tone-corrected). These contours can be used to estimate these quantities over a maximum range from 125 to 1500 meters from the aircraft during ground operation for standard meteorological conditions. Measurements were also made at more than 40 locations where maintenance and ground crews must typically be located during normal operations. A-weighted and C-weighted overall sound levels and permissible exposure times were determined for personnel at these locations with and without ear protection. Preferred speech interference levels were also determined. Author (GRA)

**N71-20847#** Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.

**LOW-SPEED WIND-TUNNEL TESTS ON A WING-FUSELAGE MODEL WITH AREA SUCTION THROUGH PERFORATIONS AT THE LEADING-EDGE FLAP KNEE**

S. F. J. Butler and J. A. Lawford London Aeron. Res. Council

1970 59 p refs Supersedes RAE-TR-67153; ARC-29756  
(ARC-R/M-3640; RAE-TR-67153; ARC-29756) Copyright. Avail:  
NTIS; HMSO: £1.50; BIS: \$5.40

Distributed suction may be preferable to tangential blowing as a method of boundary layer control to achieve high lift for civil aircraft, because of its lower flow rates and power requirements. Tests using practical perforated suction surfaces at the knee of full span leading edge flaps are reported, for conventional hinged flaps and for an extending area arrangement having increased knee radius. Stalling incidence increased progressively with suction rate. Flow requirements were insensitive to perforation arrangement and were little affected by simulated heavy rain; they were significantly reduced by increase of open-area ratio (with accompanying fall of plenum chamber depression and suction power) and increased by surface imperfections and intersurface leaks. Author (ESRO)

**N71-20848#** Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.

**INTERFERENCE EFFECTS AT  $M = 8.5$  OF WIRES AND PROBES ON THE WAKE OF A MAGNETICALLY SUSPENDED ROUNDED BASE CONE**

J. F. W. Crane London Aeron. Res. Council 1970 25 p refs  
Supersedes RAE-TR-70023; ARC-32287  
(ARC-CP-1133; RAE-TR-70023; ARC-32287) Copyright. Avail:  
NTIS; HMSO: 35p; BIS: \$1.40

Transverse and axial probes and wires in the wake produce two types of interference with the wake. With transverse probes and wires the effect is to narrow the wake shock diameter and move its source downstream. With axial probes and wires there is an opposite effect. The former is apparent when the probe is within three base diameters of the model, and the latter is apparent when the edge of the viscous core is approached from within. Author (ESRO)

**N71-20849#** Royal Aircraft Establishment, Farnborough (England). Engineering Physics Dept.

**AIRFLOW RATE REQUIREMENTS IN PASSENGER AIRCRAFT**

E. A. Timby London Aeron. Res. Council 1970 30 p refs  
Supersedes RAE-TR-69228; ARC-31984  
(ARC-CP-1136; RAE-TR-69228; ARC-31984) Copyright. Avail:  
NTIS; HMSO: 40p; BIS: \$1.60

Airflow requirements for cabins of passenger transport aircraft are considered from the aspects of breathing, temperature control, odor control, pressurization, and equipment cooling. In supersonic aircraft the consequences of a pressurization failure and the requirements of equipment cooling are likely to prevent much reduction in airflow below current figures. In subsonic aircraft the airflow could be reduced for pressurization but is likely to be dictated by odor control on which information is lacking under representative conditions. The minimum engine air bleed rate would occur for a system which recirculates and purifies a proportion of the cabin air. Development of cabin air distribution systems would be required if airflow is to be reduced. Author (ESRO)

**N71-20857#** British Aircraft Corp., Filton (England). Electronics and Space Systems.

**CONCORDE FLIGHT TEST INSTRUMENTATION**

T. T. Walters 1970 34 p Presented at the 6th Intern. Aerospace Instrumentation Symp., Cranfield, Engl., Mar. 1970  
(ESS/ES-13) Avail: NTIS

The equipment used for flight data recording in the Concorde prototype 002 is described and particular reference to the digital system which is used for the recording of quasistatic parameters is made. The major developments in the instrumentation for the preproduction aircraft are also described. Author (ESRO)

**N71-20859#** Entwicklungsring Nord, Bremen (West Germany).  
**EUROPEAN EXPERIMENTAL RESEARCH ON RE-ENTRY VEHICLE CONFIGURATIONS**

H. Tolle 1970 40 p refs Presented at the 4th EUROSPACE US-European Conf., Venice, 22-25 Sep. 1970  
Avail: NTIS

The tests performed in French and German wind and shock tunnels for studying the thermal and stability behavior of some configurations of reentry vehicles in different flow regions, are listed. ESRO

**N71-20902#** Aeronautical Research Council (Gt. Brit.).  
**CIVIL AIRCRAFT AIRWORTHINESS DATA RECORDING PROGRAMME. SPECIAL EVENTS RELATING TO AIRSPEED CONTROL AND HANDLING (JANUARY 1968 TO FEBRUARY 1969)**

1970 41 p refs Supersedes RAE-TR-69238; ARC-32354  
(ARC-CP-1135; RAE-TR-69238; ARC-32354) Copyright. Avail:  
NTIS; HMSO: 55p; BIS: \$2.20

A small number of jet aircraft in normal airline service are fitted with recorders which produce continuous trace records of airworthiness data for 14 parameters. Throughout the recording period the records have been searched for unusual occurrences, and each one has been studied to determine its nature and, where possible, its cause. A selection of events relating to airspeed control and handling recorded between January 1968 and February 1969 is described. Author (ESRO)

**N71-20922#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**A DISCUSSION OF THE CONTROL SYSTEMS OF BALLISTIC ROCKETS**

Kuang-Ch'u I 11 Sep. 1970 9 p Transl. into ENGLISH from Hang K'ung Chih Shih (Mainland China), no. 4, 1960 p 1-2  
(AD-717096; FTD-HT-23-575-70) Avail: NTIS CSCL 16/4

Russia launched two multistage ballistic missiles in 1960. The deviation of the landing point with respect to trajectory range was only one sixth-thousandth and the deviation of speed of flight was three-one-hundred-thousandths, which indicated that a condition of high perfection had been reached in rocket control systems. The operating principles of rocket control systems were introduced. The function of rocket control systems was explained. A block diagram and three major components of the automatic stabilizer were discussed. These components are: position fixing element; amplification/conversion device and steering mechanism. Finally, speed measurement mechanisms were brought up since target accuracy is greatly influenced by errors in speed. What the author introduced was simply a concept of control system equipment. Author (GRA)

**N71-20924#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**UTILITY AIRCRAFT**

B. Lyanov 23 Oct. 1970 11 p Transl. into ENGLISH from Nauk.-Tekhn. Obshchestva SSSR (Moscow), v. 88, no. 4, 1966 p 30-33  
(AD-717053; FTD-HT-23-122-70) Avail: NTIS CSCL 1/3

Discussed briefly are some of the problems which were encountered in the riveting and welding of D16T and V95T high-strength aluminum aircraft alloys, and which led to the development of the glue-welding technique used extensively in the construction of AN-24 aircraft (fuselage - 67 percent glue-welded). An 11-month comprehensive testing program is described and the successful use of FL-4S adhesive, cured 7 hrs at 140 degrees, is mentioned. The glue-welding technique is described in general

terms and the subsequent use of KLN-1 and VK-1MS epoxy-thiokol resins (polymerized at 145-150 degrees centigrade) is reported.  
Author (GRA)

**N71-20938#** Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.

**AN ANALYSIS OF OBLIQUE AND NORMAL DETONATION WAVES**

L. H. Townend London Aeron. Res. Council 1970 45 p refs  
Supersedes RAE-TR-66081; ARC-28317  
(ARC-R/M-3638; RAE-TR-66081; ARC-28317) Copyright. Avail:  
NTIS; HMSO: £ 1.10; BIS: \$4.05

Plane detonation waves are analyzed, on the assumption that the ratio of specific heats and the molecular weight are constants. Heat release is quoted in terms of a dimensionless parameter  $F$ , such that, for Chapman-Jouguet detonations  $F = 1$ , for any strong detonation 1 less than  $F$  less than 2, and for shock waves  $F = 2$ . Wave properties are shown to be functions either of heat release and the component of upstream Mach number normal to the wave, or of heat release and both normal and streamwise components of upstream Mach number. The expressions can be used to generalize existing programs for flows with two dimensional or axisymmetric shock waves; they thus allow computation of two dimensional or axisymmetric flow fields formed between a body and a detonation wave.  
Author (ESRO)

**N71-21006\*** National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

**EVENT RECORDER Patent**

James M. Russell, III and William E. Fox, inventors (to NASA)  
Issued 21 Nov. 1967 (Filed 30 Dec. 1965) 3 p Cl. 346-50  
(NASA-Case-XLA-01832; US-Patent-3,354,462;  
US-Patent-Appl-SN-517858) Avail: US Patent Office CSCL 14B

An event recorder with a constant speed motor which rotates a recording disc is described. An ignitable coated wire that produces carbon when subjected to an electrical current is positioned immediately above the recording disc. When an event occurs, a current is energized causing carbon to be deposited on the disc. The angular position of the carbon spot with respect to a known reference mark indicates the time of the event.

Official Gazette of the U.S. Patent Office

**N71-21085#** Serendipity Associates, Arlington, Va.

**A STUDY OF THE MAGNITUDE OF TRANSPORTATION NOISE GENERATION AND POTENTIAL ABATEMENT. VOLUME 2: MEASUREMENT CRITERION Final Report**

Nov. 1970 117 p refs  
(Contract DOT-OS-A9-018)  
(OST-ONA-71-1-Vol-2) Avail: NTIS

A-weighted sound level (in dbA) and noise pollution level (in dbA) were examined to determine their relationships to other measures and their prediction of reaction; i.e., loudness, annoyance, noisiness. The A-weighted sound level, on the average, correlated as well with subjective response as the other measures. Only for jet aircraft pure tones was there a significant predictive performance difference between effective perceived noise level and dbA. Average community response measures were developed for aircraft and motor vehicle noise. Using the aircraft noise and number index and motor vehicle traffic noise index data, the noise pollution level was shown to correlate as well with average community response as both of the measures.  
Author

**N71-21087\*#** Systems Technology, Inc., Hawthorne, Calif.

**PRINCIPLES FOR THE DESIGN OF ADVANCED FLIGHT DIRECTOR SYSTEMS BASED ON THE THEORY OF MANUAL**

**CONTROL DISPLAYS**

D. H. Weir, R. H. Klein, and D. T. McRuer Washington NASA  
Mar. 1971 97 p refs  
(Contract NAS2-3746)  
(NASA-CR-1748) Avail: NTIS CSCL 01D

Recent developments in the theory of manual control displays lead to principles for analytical design of flight directors, given the dynamics of the (augmented) vehicle and its manual control system. The theory shows that there are effective director/vehicle controlled element dynamics which are preferred from the standpoint of pilot response and system performance. Other considerations include response compatibility, display consistency, director/vehicle system which satisfies both pilot-centered and guidance control requirements. The analytical process for longitudinal control of transport-type aircraft during landing approach is discussed.  
Author

**N71-21102\*#** Air Force Avionics Lab., Holloman AFB, N.Mex. Detachment 1

**OVERVIEW OF THE AF AVIONICS LABORATORY REENTRY ELECTROMAGNETICS PROGRAM**

Robert Rawhouser /in NASA. Langley Res. Center The Entry Plasma Sheath and its Effects on Space Vehicle Electromagnetic Systems, Vol. 1 1970 p 3-17

Avail: NTIS HC\$9.00/MF\$0.95 CSCL 20I

Studies of wave propagation through plasma since 1959 are reported. Interest was initially generated by the Dyna Soar program, which was to be a manned space vehicle. Model tests were run in the hotshot tunnels. More significant than the results was the realization of the magnitude of the problem. A program was inaugurated to study the problem from numerous approaches, and many theoretical problems were solved. Shock tube and tunnel experiments on various configurations yielded results. Reflectometers to yield antenna impedance measurements in the presence of plasma were installed on some early Atlas missiles, ASSET vehicles, and Trailblazer 2 vehicles. Four Trailblazers were instrumented and flown to obtain data on wave propagation through plasma and plasma noise. Considerable effort was placed on methods of alleviating the effects of plasma. Methods chosen for the program were the aerodynamic gas spike, a strong steady magnetic field, and the modulated electron beam. The latter two were difficult to instrument. In addition, the laboratory sponsored two Athena missile flights to investigate plasma influence on electromagnetic countermeasures.  
Author

**N71-21166#** Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

**MECHANICS OF CAPTIVE AERONAUTICS**

B. I. Khalesspiskii 10 Nov. 1970 128 p refs Transl. into ENGLISH from Mono. Mekh. Priv. Vozdukhoplavaniy (Moscow), 1945 p 1-116  
(AD-717015; FTD-MT-24-259-70) Avail: NTIS CSCL 1/1

Contents: Aerostatics; Aerodynamics; Lifting-operating characteristics of a balloon; Balloon dynamics. GRA

**N71-21169#** National Transportation Safety Board, Washington, D.C.

**MIDAIR COLLISION INVOLVING AMERICAN AIRLINES FLIGHT 30, BOEING 707-323 N7595AA AND LINDEN FLIGHT SERVICE CESSNA 150, N60942, AT EDISON, NEW JERSEY, 9 JANUARY 1971**

3 Mar. 1971 12 p  
(SB-71-28) Avail: Issuing Activity

The facts, circumstances, and conditions of a midair collision between a Boeing 707 and a Cessna 150 aircraft at Edison, New

Jersey on January 9, 1971 are presented. The information is interim in nature pending completion of the investigation and issuance of a formal report. Author

distance between the shield and the jet axis is small - that is, when the jet is immediately adjacent to the shield. This part of the sound can be attributed to the radiation from a distribution of acoustic dipoles which are produced by the turbulent pressure fluctuations on the shield surface. The quadrupole radiation of the free turbulence is reduced by the shield. Author

**N71-21205#** Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.

**SOME FLIGHT AND WIND-TUNNEL LONGITUDINAL STABILITY MEASUREMENTS ON THE BAC SLENDER-WING AIRCRAFT**

C. S. Barnes and R. Rose London Aeron. Res. Council 1970 25 p refs Supersedes RAE-TR-70054; ARC-32330 (ARC-CP-1134; RAE-TR-70054; ARC-32330) Copyright. Avail: NTIS: HMSO: 35p; BIS: \$1.40

Preliminary flight measurements of the longitudinal trim and dynamic stability of the BAC 221 aircraft have been made. The flight measurements are of reasonable quality in spite of difficulties associated with the aileron control system, an early instrumentation standard, and the handling characteristics of the aircraft at high incidence. Useful comparisons with wind tunnel results are made, and the agreement is generally reasonable, although some unexplained differences remain. Flight and wind tunnel tests to investigate the differences are planned. Author (ESRO)

**N71-21223#** Royal Aircraft Establishment, Farnborough (England).

**ON THE EFFECT OF GUSTS AND CROSSWIND ON THE DYNAMIC RESPONSE OF AIRCRAFT IN THE LANDING APPROACH [BOEINFLUSSE AUF DIE DYNAMIK EINES FLUGZEUG BEIM LANDEANFLUG]**

P. Hamel et al Oct. 1970 33 p refs Transl. into ENGLISH of the publ. 'DGIR Jahrestagung 1969, Vortrag No. 52' (RAE-Lib-Trans-1524) Avail: NTIS

The response of a slender delta aircraft to vertical and lateral gusts has been investigated with the following results. (1) Steady sideslip - as in crosswind - produces strong inter-mode coupling which considerably alters the characteristics of the longitudinal short period and of the roll subsidence mode. (2) Wind shear in the earth boundary layer increases the sensitivity to lateral gusts. (3) It is possible to reduce the gust sensitivity both of the longitudinal and the lateral motion by suitable choice of aerodynamic properties. Simple criteria are given to define these conditions. Author

**N71-21226#** Royal Aircraft Establishment, Farnborough (England).

**ON THE GENERATION OF SOUND RESULTING FROM THE PASSAGE OF A TURBULENT AIR JET OVER A FLAT PLATE OF FINITE DIMENSIONS [ZUR SCHALLERZEUGUNG DURCH EINEN TURBULENTEN LUFSTRAHL UEBER EINER ENDLICH GROSSEN EBENEN PLATTE]**

F. R. Grosche Oct. 1970 110 p refs Transl. into ENGLISH of Mitt. Max-Planck-Inst. Stromungsforsch. Aerodyn. Versuchsanstalt (Gottingen), no. 45, 1969 (RAE-Lib-Trans-1460) Avail: NTIS

The generation of sound by a jet of air of high subsonic velocity, issuing from a slot nozzle and passing over a rigid, flat plate of finite dimensions was investigated. Configurations of this type are of interest in, among other fields, the screening of the jet noise from jet installations. Accordingly, the plate is also termed a shield. The relevant basic concepts of aerodynamic sound generation and a description of the measurements made are presented. In particular, the following points have been investigated: (1) the dependence of the acoustic far field on the shield length, on the distance between the jet axis and the shield, and on the jet velocity and (2) the sound source distribution in the turbulent jet, both with and without a shield. Additional sound is generated in the neighborhood of the trailing edge of the shield, when the

**N71-21258#** Joint Publications Research Service, Washington, D.C.

**FAIRINGS FOR AIRCRAFT ANTENNAS**

B. A. Prigoda et al 12 Mar. 1971 10 p Transl. into ENGLISH from Obtekateli Antenn Letatel'nykh apparatov (Moscow), 1970 p 181-192

(JPRS-52608) Avail: NTIS

Calculations of electromagnetic wave transmission through a curvilinear dielectric wall and for fairing with optimal transparency are discussed. Cylindrical, hemispherical, conical, and ogival fairings are considered. A device is described for speeding the calculations of the angles of incidence of the beams on the fairing wall, and only the center portion of the fairing, receiving most of the radiation, is used in the calculations. N.E.N.

**N71-21269** California Univ., Berkeley.

**A NUMERICAL METHOD FOR CALCULATING STEADY UNSYMMETRICAL SUPERSONIC FLOW PAST CONES**

Daniel Ejike Ndefo (Ph.D. Thesis) 1969 85 p

Avail: Univ. Microfilms: HC \$4.40/Microfilm \$3.00 Order No. 70-6175

Telenin's numerical method is adapted to the problem of steady supersonic flow past pointed conical bodies at yaw. The method is formulated for cones of circular cross-sections with the intention of determining bounded analytic solutions uniformly valid in the region between the shock and cone surfaces. Attention is focused on the nature of the entropy field and the behavior of the streamlines as influenced by variations in the free-stream conditions. As an example, numerical computations are carried out for flow past a circular cone of semi-apex angle 20 deg yawed at angles of attack varying from 0 deg to 20 deg with respect to a free-stream of Mach number 3.53. Solutions are compared with experimental results and with solutions based on other numerical methods. The entropy layer is shown to be very thin at small angles of attack but relatively thick at large angles of attack. The directions from which the streamlines enter the vortical singularity are found to depend on the angle of attack. Dissert. Abstr.

**N71-21284#** National Research Council of Canada, Ottawa (Ontario).

**STRATOSPHERIC TURBULENCE AND TEMPERATURE GRADIENTS MEASURED BY AN RB-57F. COLDSCAN FLIGHTS 19 TO 56**

J. I. Mac Pherson (Natl. Aeron. Estab.) and E. G. Morrissey (Natl. Aeron. Estab.) Nov. 1970 80 p refs (LR-542) Avail: NTIS

Since January 1969, a weather reconnaissance aircraft has carried a special instrumentation system to measure and record stratospheric turbulence and horizontal temperature gradients encountered at altitudes from 40,000 to above 60,000 feet, altitudes to be flown by the supersonic transports. To date 57 data flights have been flown, covering 82,000 nautical miles of the central and western United States, Ontario and the Pacific Ocean south of Panama. Detailed accounts of a selection of 20 events from Flights 19 through 56 show significant temperature gradients or light to moderate turbulence. These presentations include time histories of the recorded variables, flight tracks showing event positions, and meteorological analyses. Data are presented on the correlation

between measured stratospheric turbulence and horizontal temperature gradients, on the altitude and geographical distribution of the turbulence and temperature change encounters, and on the positions of the recorded incidents relative to the jet stream.  
Author

**N71-21320\*#** TRW Systems Group, Redondo Beach, Calif.  
**EXPERIMENTAL ASPECTS OF HOLOGRAPHIC INTERFEROMETRY**

Ralph F. Wuerker [1969] 13 p refs Submitted for publication  
(Contract NAS2-4992)  
(NASA-CR-114291) Avail: NTIS CSCL 20E

Industrial applications of holography and holographic interferometry are discussed including the recording of high speed elusive phenomena, aerodynamic visualization, nondestructive testing, and contouring. Optical systems insensitive to the incoherence of laser illuminators are cited. Holography with Q-switched ruby lasers are emphasized using optical arrangements to compensate for spatial and temporal incoherence of the illuminators. J.M.

**N71-21363#** Army Aviation Systems Test Activity, Edwards AFB, Calif.

**INVESTIGATION OF ENGINE RIGGING, AIRSPEED AND ROTOR RPM EFFECTS ON STEADY STATE AUTOROTATIONAL PERFORMANCE** Final Report, Apr. 1968 - Dec. 1969

John B. Fitch and John J. Shapley, Jr. Dec. 1970 35 p refs  
(AD-717047; USAASTA-70-23) Avail: NTIS CSCL 1/3

An investigation was conducted to define the effects of various airspeeds, rotor speeds, engine rigging and gross weights on a UH-1C helicopter during autorotation. Results of the investigation confirmed previous qualitative conclusions: that the use of low rotor speed to obtain maximum glide distance can be hazardous, especially at high gross weight conditions; and that current autorotation rate of descent information in operators manuals is insufficient for the operators use. The investigation further revealed that with a normal engine rigging, there is a measurable amount of engine output torque at low rotor speeds (310 rpm and below) during practice autorotations. This situation, encountered in a training environment, could produce a false sense of security in an individual faced with an actual emergency. Although the operational pilot cannot duplicate controlled test conditions, he should understand normal performance limits and the consequences of exceeding those limits. The report furnishes UH-1C autorotational data not currently available to the operator which should be incorporated into the appropriate manuals. Author (GRA)

**N71-21368#** Battelle Memorial Inst., Columbus, Ohio.  
**MICROWAVE LANDING GUIDANCE SYSTEMS INITIAL CONCEPT VALIDATION TESTS** Final Report

George T. Ruck Dec. 1970 62 p  
(Contract F33615-70-C-1795)  
(AD-717183; AFFDL-TR-70-156) Avail: NTIS CSCL 17/7

The report outlines in a very general sense an Air Force microwave landing guidance system concept-validation program. This is to provide the necessary background for the bulk of the report which is concerned with an identification of the critical areas of the RTCA signal format and system description, and some initial tests designed to validate some of the critical features of the RTCA format. The initial tests addressed are laboratory and field tests that can be conducted with standard laboratory equipment and/or equipment currently under procurement by AFFDL. These tests are concerned with those critical areas of the RTCA format that can be validated without flight testing and without requiring special purpose test hardware other than that which will be available early in 1971. Initial flight tests necessary for validating certain elements

of the guidance system have not been specifically discussed since the initial laboratory and field tests must be conducted in order that meaningful flight test plans can be prepared and the flight test data analyzed. Some discussion is also given of the facilities required for the conduct of a validation test program. Since facility procurement often involves long lead times, the required facilities must be identified as early as possible. Author (GRA)

**N71-21408\*#** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.  
**ACOUSTIC SCATTERING BY A POROUS ELLIPTIC CYLINDER WITH NONLINEAR RESISTANCE**

William Edward Zorumski (Ph.D. Thesis Virginia Polytech. Inst.) Mar. 1971 109 p refs  
(NASA-TM-X-67019) Avail: NTIS CSCL 20A

Equations for high intensity acoustic waves are derived from the general equations governing a compressible isotropic Newtonian fluid. The integral conservation laws of continuum mechanics are used to determine a general set of laws, similar to shock wave relations, which describe the interaction of these waves with thin porous sheets of material. A special case of these laws, where the velocity normal to the sheet is continuous and the pressure drop across the sheet is a nonlinear function of the normal velocity, is used to study acoustics problems with nonlinear material effects. Numerical, approximate, and exact solutions are obtained from the one-dimensional problem where two regions are coupled through a porous sheet with nonlinear resistance. Solutions for scattering from a thin rigid porous elliptic cylindrical shell are found in terms of Mathieu functions. Coupling terms in these equations are given by integrals involving Mathieu functions which are evaluated by exact methods. Author

**N71-21475\*** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**HYPERSONIC TEST FACILITY Patent**

Frank L. Clark, Charles B. Johnson, Wayne D. Erickson, and Roger I. Buchanan, inventors (to NASA) Issued 18 Jul. 1967 (Filed 29 Jul. 1965) 8 p Cl. 73-343 Continuation-in-part of US Patent Appl. SN-266107, filed 18 Mar. 1963  
(NASA-Case-XLA-05378; US-Patent-3,331,246;  
US-Patent-Appl-SN-484156) Avail: US Patent Office CSCL 14B

A hypersonic test facility for ablation studies and other testing of aeronautic and space vehicles under conditions of high pressure and high temperature is described. The principal feature of the test facility is the incorporation of a heat exchange facility for heating a gas under high pressure from room temperature to more than 3,000 degree R, with the further capability of continuous operation for a period of fifteen minutes or more while maintaining a steady state high exit gas temperature.

Official Gazette of the U.S. Patent Office

**N71-21493\*** National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

**NACELLE AFTERBODY FOR JET ENGINES Patent**

Mark R. Nichols, inventor (to NASA) Issued 17 Oct. 1967 (Filed 15 Nov. 1966) 13 p Cl. 239-265.19 Continuation-in-part of US Patent Appl. SN-262297, filed 28 Feb. 1963  
(NASA-Case-XLA-10450; US-Patent-3,347,466;  
US-Patent-Appl-SN-594587) Avail: US Patent Office CSCL 21E

An afterburner-equipped jet engine nacelle is described. It involves the addition of several three-dimensional bodies, or horns, extending aft from the steep portion of the boattail portion of the nacelle and from any blanked-off portion of the nacelle base. In this way, a slotted surface is formed aft of the annular base surrounding the nozzle of the primary jet. This addition is designed, in accordance with the principles of the equivalent-body theory, to

effectively increase the ratio of nacelle body length to the maximum diameter of the body, and to reduce the slope of the boattail. Experiments indicate that the afterbodies can be hinged to the nacelle and diverted by actuation to provide a thrust-reversing device.

D.L.G.

**N71-21508\*** National Aeronautics and Space Administration  
Lewis Research Center, Cleveland, Ohio.

**ANALYTICAL STUDY OF THE EFFECTS OF GEOMETRIC CHANGES ON THE FLOW CHARACTERISTICS OF TANDEM-BLADED COMPRESSOR STATORS**

Nelson L. Sanger Washington Mar. 1971 62 p refs  
(NASA-TN-D-6264; E-5876) Avail: NTIS CSCL 20D

The effects of changes in geometry on the performance of 15 tandem-bladed statots is reported. Five geometrical parameters were evaluated for flow only in the two-dimensional plane. Using results from this study a tandem blade was designed for which the analytically calculated loss was relatively small. A parameter that approximated the incidence of the mean flow on the rear blade showed an ability to identify effective tandem blade configurations. Boundary-layer calculations indicated that the shorter chord length tandem blade segments could not sustain as high a suction surface diffusion as conventional solid blade sections.

Author

**N71-21512\*** National Aeronautics and Space Administration,  
Lewis Research Center, Cleveland, Ohio.

**PRELIMINARY THERMAL PERFORMANCE ANALYSIS OF THE SOLAR BRAYTON HEAT RECEIVER**

Raymond K. Burns Washington Mar. 1971 41 p refs  
(NASA-TN-D-6268; E-6042) Avail: NTIS CSCL 10A

The solar heat receiver, a combination heat exchanger and heat storage device, is designed to transfer 40 kilowatts of heat to the working gas of a Brayton engine. During a sun period of an Earth orbit, a parabolic collector is used to focus solar radiation into the receiver. Excess input solar energy is stored as heat of fusion of lithium fluoride and is withdrawn by the Brayton cycle during shade periods. The analysis predicted an acceptable variation in outlet gas temperature between 1490 and 1550 F (1080 and 1120 K) for a nominal design value of 1500 F (1089 K).

Author

**N71-21523\*** Naval Civil Engineering Lab., Port Hueneme, Calif.  
**AIRFIELD MARKING PAINTS FOR ASPHALTIC PAVEMENTS**

Richard W. Drisko Dec. 1970 71 p refs  
(AD-716755; NCEL-TR-705) Avail: NTIS CSCL 11/3

Specially formulated marking paints for striping airfields were field tested. The polyvinyl acetate paint at CBC, Port Hueneme was still in excellent condition 4 years after application. In all cases single-thickness ratings were as good as or better than corresponding double-thickness ratings, especially for the double-thickness alkydratings. The polyvinyl acetate paint performed best on the runway at Guam, but the three oleoresinous phenolic varnish paints and one of the two alkyd paints performed slightly better on the roadway. On a runway at NAS, Point Mugu the polyvinyl acetate paint performed the best of the six paints tested. Miscellaneous problems with airfield marking paints at other activities are discussed and solutions presented. Laboratory tested included analyzing water-emulsion paints for possible use as marking paints and developing simple test procedures for identifying alkyd and chlorinated resins in fresh and weathered marking paints.

Author (GRA)

**N71-21600\*** Catholic Univ. of America, Washington, D.C. Dept. of Space Science and Applied Physics.

**THREE DIMENSIONAL PLANING AT HIGH FROUDE**

**NUMBER Final Report**

D. P. Wang and Paul Rispin 19 May 1970 34 p refs  
(Contract N00014-67-A-0377-0006)  
(AD-717067; Rept-70-003) Avail: NTIS CSCL 13/10

The steady motion of a planing surface of moderate aspect ratio at small angles of attack is considered. Linearized theory is used with a square-root type of pressure singularity representing the flow near the leading edge. As asymptotic solution for the pressure distribution on the planing surface at large Froude number (or small beta, the inverse of the Froude number) is sought. The lowest order term of the pressure distribution, obtained by setting beta equal to zero, is found to be the same as the pressure distribution on the lower side of the corresponding thin wing. Higher order terms in beta are obtained by an iteration process. Explicit solutions are obtained to order beta squared for rectangular planforms. Numerical results are calculated for rectangular flat plate planing surfaces of aspect ratios from 0.5 to 2.0. It is found that for large aspect ratios the lift coefficient is reduced by the gravity effect and for small aspect ratios it is increased, the dividing aspect ratio being about 1.5. The results compare reasonably well with experimental data.

Author (GRA)

**N71-21607\*** National Transportation Safety Board, Washington, D.C.

**AIRCRAFT ACCIDENT REPORT: PILGRIM AVIATION AND AIRLINES, INCORPORATED, DE HAVILLAND TURBO PROP DHC-6, N12PM, IN LONG ISLAND SOUND NEAR WATERFORD, CONNECTICUT, 10 FEBRUARY 1970**

27 Jan. 1971 39 p

(NTSB-AAR-71-1; SA-418) Avail: NTIS

On February 10, 1970, Pilgrim Aviation and Airlines, Inc., scheduled air taxi Flight 203, a Turbo Prop De Havilland DHC-6, Twin Otter, N124PM, was ditched in Long Island Sound near Waterford Connecticut. The ditching occurred approximately 2 hours and 16 minutes after Flight 203 departed from Trumbull Airport, Groton, Connecticut, on an Instrument Flight Plan and clearance in instrument weather conditions for a scheduled flight to the John F. Kennedy International Airport, Jamaica, New York. The flight held in the New York area for an extended period, and then diverted to the Tweed Airport at New Haven, Connecticut, where it attempted and missed an instrument landing approach. At the time of the ditching, the flight was attempting to return to Trumbull Airport.

Author

**N71-21623\*** Air Force Systems Command, Wright-Patterson AFB, Ohio. Air Force Flight Dynamics Lab.

**CRITICAL EVALUATION OF A NONUNIFORM FLOW SONIC BOOM REDUCTION CONCEPT Technical Report, Oct. 1968-Jul. 1969**

Thomas M. Weeks Sep. 1970 37 p refs

(AD-717193; AFFDL-TR-70-65) Avail: NTIS CSCL 20/1

An investigation was made of a nonuniform flow field sonic boom elimination device. The two-dimensional flow field consists of a slit jet impinging on an inclined flat plate airfoil. The report presents independent analyses of the problem as well as a critique of the analysis. The major finding is that one can expect no more than a 10% reduction in the strength of the leading edge shock wave at a thousand chord lengths from the plate when compared to the corresponding case without jet flow (same chord and lower surface pressure). Under identical conditions, a 20% reduction is found.

Author (GRA)

**N71-21624\*** Civil Aeronautics Board, Washington, D.C. Bureau of Safety.

**CIVIL AERONAUTICS BOARD ANNUAL REVIEWS OF US AIR CARRIER ACCIDENTS FOR CALENDAR YEARS 1938-1952**

## N71-21627

1971 498 p refs  
(PB-196672; CAB-BOSR-38/52) Avail: NTIS HC \$6.00/MF \$0.95 CSCL 01B

Comparatively, significant factors surrounding accidents in U.S. scheduled air carrier passenger operations during the calendar years 1951 and 1952 are reported. Detailed tabulations of accident causes, types, operational phases, etc., as well as pertinent charts, are appended. Each scheduled operator is shown in relation to the number of passengers and passenger miles flown, revenue plane miles flown, number of accidents, and resultant injuries, if any. Additionally, a composite tabulation is included which shows the division of these operations as follows: (1) domestic operations; and (2) international, U.S. flag. Author (GRA)

### N71-21627# Texas Transportation Inst., College Station. **AIR TRANSPORTATION FOR TEXAS: COMMENTARY**

John P. Doyle, Vergil G. Stover, John C. Goodknight, and Robert J. Hammons Aug 1970 33 p  
(PB-196932) Avail: NTIS CSCL 01B

The development of commercial air transportation for the state of Texas is discussed. Subjects presented are: (1) the state role, (2) inventory of facilities, (3) use of V/STOL aircraft, (4) development of transportation system, and (5) funding. Author

### N71-21628# Texas Transportation Inst., College Station. **AIR TRANSPORTATION FOR TEXAS: WORK PLAN**

John C. Goodknight and John P. Doyle Aug 1970 94 p refs  
(PB-196933) Avail: NTIS CSCL 01B

The research and development efforts anticipated and required for the preparation of the Texas Air Transportation Plan are discussed. The work plan is largely concerned with proposed procedures to be developed and used for the estimation of demand for air transportation services and facilities. The document treats three overall classes of demand: (1) commercial passengers, (2) air cargo, and (3) general aviation. Techniques suggested for forecasting demands use socioeconomic characteristics of the region as the basis for these estimates. The work plan identifies potential sources for such information and a tentative schedule for collecting these data and the generalized schedule for completion of the several phases of the Texas Air Plan Study. Author (GRA)

### N71-21629# Texas Transportation Inst., College Station. **AIR TRANSPORTATION FOR TEXAS: AIRPORT INVENTORY**

Robert J. Hammons and John P. Doyle Sep 1970 22 p refs  
(PB-196935) Avail: NTIS CSCL 01B

An inventory of existing airport facilities in the state of Texas is presented. Information from existing FAA airport records was compiled, coded and computerized. The results of this process furnished 942 pages of pertinent facts about the airports in Texas plus the capability for rapid retrieval of facts. In addition to a general listing, several other computer programs were written which provide listings of specific information of particular interest. Author (GRA)

### N71-21630# Texas Transportation Inst., College Station. **AIR TRANSPORTATION FOR TEXAS: REFERENCE, 1970**

John C. Goodknight and Gina Taylor Sep 1970 81 p refs  
Prepared in cooperation with Tex State Div. of Planning Coordination  
(PB-196936) Avail: NTIS CSCL 01B

A compilation of references on the various aspects of air

transportation for Texas is presented. Abstracts are included for a number of the individual references included in the listing. The document is organized according to the following topics: (1) aircraft, (2) airport, (3) bibliographies and reference lists, (4) commercial air carriers, (5) financing, (6) forecasts, (7) general aviation, (8) legislation and administration, (9) regional economic activity patterns and development, (10) regulation, (11) traffic control/nav aids, (12) travel patterns, and (13) V/STOL. Author (GRA)

### N71-21632# Texas Transportation Inst., College Station. **AIR TRANSPORTATION FOR TEXAS: V/STOL APPLICATIONS, 1970**

Robert J. Hammons and John P. Doyle Sep 1970 23 p refs  
(PB-19693m) Avail: NTIS CSCL 01B

V/STOL as a transportation system and the applicability of such a system to air transportation in Texas is discussed. Background information justifying a need for V/STOL systems is discussed as is current and future V/STOL aircraft designs and fixed terminal facilities necessary to support the system. These criteria are then applied to air transportation needs in the state of Texas with emphasis on intermetropolitan area V/STOL systems. While such a system is feasible in the state, no accelerated activity is recommended for the present time. Author (GRA)

### N71-21634# Ohio State Univ. Research Foundation, Columbus. **SUPERSONIC COMBUSTION AND BURNING IN RAMJET COMBUSTORS Final Report, 1 Feb. 1966 - 31 Mar. 1970**

Rudolph Edse Jun 1970 205 p refs  
(Grant AF-AFOSR-0203-67)  
(AD-716855; OSURF-2153-3; AFOSR-70-2467TR) Avail: NTIS CSCL 21/2

Induction distances, transient pressures, and wave propagation rates were determined in cylindrical tubes for detonation waves in stoichiometric hydrogen-oxygen mixtures initially at one atmosphere and temperatures ranging from 300K down to 123K. The induction distances became considerably shorter as the initial gas temperature was decreased. At temperatures from 500 to 123K the normal burning speed of stoichiometric hydrogen-oxygen mixtures was found to be proportional to the absolute temperature of the unburnt gas. High-strength shock waves were fired into lean hydrogen-oxygen mixtures to study the propagation rates of the flames behind these waves (overdriven detonations). Ignition delay times in hydrogen-nitric oxide mixtures were found to be very long. Stable detonation waves could not be produced in these mixtures. Quantum yields and induction times have been measured in flowing mixtures of hydrogen, oxygen, and chlorine to determine the feasibility of photochemically initiated supersonic combustion. Expressions have been derived to predict the induction times and quantum yields. A method has been developed for calculating the state of the gas behind a normal shock in a shock tube for the case that both the driver and the driven gas undergo chemical changes during the process. Result indicate that for dissociating hydrogen calculations based on the use of certain values of the specific heat ratio may be in error by 30% for the calculated particle speed. Author (GRA)

### N71-21638# California Univ., Berkeley. **TRANSPORTATION SYSTEM NOISE GENERATION, PROPAGATION, AND ALLEVIATION, PHASE 1, PART 1**

Robert Horonjeff and Walter W. Soroka Sep 1970 181 p refs  
(Contract DOT-OS-A9-118)  
(PB-196391; DOT-OST-ONA-71-2-1-Pt-1) Avail: NTIS CSCL 20A

Contents: Progress report in research on noise annoyance; A preliminary study of sound propagation around obstacles; An

analysis of noise levels generated by jet transport aircraft. On measuring the cost of noise from subsonic aircraft. Progress report on land use, community impact, and land value project. GRA

**N71-21663#** Civil Aeronautics Board, Washington, D.C. Bureau of Safety.

**CIVIL AERONAUTICS BOARD ANNUAL REVIEWS OF US AIR CARRIER ACCIDENTS FOR CALENDAR YEARS 1953 - 1957**

1971 481 p refs

(PB-196673; CAB-BOSR-53157) Avail: NTIS HC \$6.00/MF \$0.95 CSCL 01B

Contents: U.S. air carrier accidents; General aviation accidents. GRA

**N71-21665#** Civil Aeronautics Board, Washington, D.C. Bureau of Safety.

**CIVIL AERONAUTICS BOARD ANNUAL REVIEWS OF AIR CARRIER ACCIDENTS FOR CALENDAR YEARS 1958 - 1963**

1971 469 p refs

(PB-196674; CAB-BOSR-58/63) Avail: NTIS HC \$6.00/MF \$0.95 CSCL 01B

The record of aircraft accidents, incident to flight, which occurred in U.S. Air Carrier operations during the calendar years 1958 - 1962 is reported. It includes a statistical recapitulation of all accidents, and a brief description of each accident along with the probable cause as determined by the Civil Aeronautics Board.

Author (GRA)

**N71-21676#** Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.

**A PRELIMINARY STUDY OF ACTIVELY CONTROLLED AIR CUSHION VEHICLE SUSPENSIONS**

David A. Hullender, David N. Wormley, and Herbert H. Richardson 15 Jun. 1970 161 p refs

(Contract C-85-65)

PB-196465; EPL-70-76110-11) Avail: NTIS CSCL 13F

The primitive vehicle suspension system coupling a simple vehicle model point contact with a two-dimensional guideway having random irregularities is defined. The optimum linear suspension which minimizes a linear combination of vehicle heave acceleration (passenger comfort) and suspension-guideway displacement (suspension excursion) is synthesized using Weiner-Hopf filter theory. The mechanics of flexible base externally pressurized air cushion vehicle suspensions are discussed, including the use of a feedback control flow into the cushion region.

Author (USGRDR)

**N71-21707#** Army Aviation Systems Command, St. Louis, Mo. Directorate of Flight Standards and Qualification.

**A STUDY OF THE ARMY HOT DAY DESIGN HOVER CRITERION**

Robert Bellaire and William Bousman Aug. 1970 118 p refs

(AD-717025; ADS-TN-68-1) Avail: NTIS CSCL 1/3

A study is presented of the Army hot day design hover criterion. Models are developed to represent rotorcraft, cost, environment and operation, and these models are integrated to examine the effectiveness and cost of the rotorcraft as a function of design altitude and temperature. Although no optimum design hover criterion can be derived, the effects of rotorcraft type and size, and performance degradation to be expected in the field are identified, and the appropriate range of design altitudes and temperatures are obtained.

Author (GRA)

**N71-21727#** General Electric Co., Philadelphia, Pa. Missile and Space Div.

**PROGRESS AND GOALS FOR AERONAUTICAL APPLICATIONS OF SPACE TECHNOLOGY**

Daniel J. Fink and Roy E. Anderson [1970] 9 p Presented at EUROSPACE (4th US-European Conf.), Venice, 25 Sep. 1970

(PIB-A-57) Avail: Issuing Activity

Current and projected technological applications are briefly described, using VHF satellite communication as an example. Ranging experiments with ATS 1 and ATS 3 satellites are explained and illustrated with latitude determinations of Gander, Newfoundland, and position fixing for an aircraft over the North Atlantic. The quality of voice communication is compared for HF with no satellite link, ground to ground with ATS 3 satellite link, aircraft to ground via ATS 3 link, and ship to land with ATS 3 link. It is recommended that a comparison should be made of the performances of HF and VHF for transoceanic communications, the VHF satellite performance should be weighed against cost, and the L-band technology should be developed.

N.E.N.

**N71-21796#** California Univ., Berkeley.

**TRANSPORTATION SYSTEM NOISE GENERATION, PROPAGATION AND ALLEVIATION. PHASE 1: PART 2: BIBLIOGRAPHY**

Robert Horonjeff and Walter W. Soroka Sep. 1970 217 p refs

(Contract DOT-OS-A9-118)

(PB-196392; DOT-OST-ONA-71-2-Pt-2) Avail: NTIS CSCL 20A

A bibliography of research on noise annoyance was collected and presented in sections with summaries of research in each section and annotations for many articles. Special emphasis was placed on a review of existing and possible methodologies in research and on the collection of relevant articles from diverse disciplines. Sections are included on loudness and noisiness, psychological responses, survey research, physiological responses, effects on performance, single attribute scaling, multiattribute scaling, community noise, noise propagation, general discussions of the problem of noise, and bibliographies.

Author (GRA)

**N71-21803#** Massachusetts Inst. of Tech., Cambridge. Aeroelastic and Structures Research Lab.

**BRIEF HANDBOOK FOR THE SUM OF TWO HARMONICS**

John Dugundji and Prakash Hore Nov. 1970 48 p

(Contract F44620-69-C-0091)

(AD-717201; ASRL-TR-159-2; AFOSR-70-2515TR) Avail: NTIS CSCL 20/11

A systematic illustration of the sum of two harmonics is presented. Various patterns for the response such as waviness, beats, and jiggles are obtained. The general relation of these patterns to the frequencies and amplitudes of the two harmonics is indicated. The patterns are shown to be repeatable for phase shifts of generally less than 360 degrees between the two harmonics. Numerous and systematic examples for the responses are given over a wide range of frequencies, amplitudes, and phase angles.

Author (GRA)

**N71-21842#** National Environmental Satellite Center, Washington, D.C.

**CALCULATION OF CLEAR COLUMN RADIANCES USING AIRBORNE INFRARED TEMPERATURE PROFILE RADIOMETER MEASUREMENTS OVER PARTLY CLOUDY AREAS**

William L. Smith Mar. 1971 18 p refs

(NOAA-TM-NESS-28) Avail: NTIS

In June 1970, a brassboard version of the infrared temperature profile radiometer was flown on the NASA Convair-990. This flight was made primarily to obtain measurements to test the hypothesis that radiance propagating from clear portions of a partly cloudy field could be calculated directly from the total radiance measurement over the field. Such clear column radiances are needed if one is to determine the temperature and water vapor profiles of the atmosphere to the earth's surface. Sample results presented show these calculations are feasible, and indicate that measurements from the medium resolution scanning radiometers to be used on future polar-orbiting satellites can be used to provide global soundings.

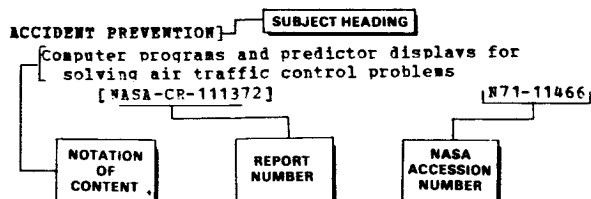
Author

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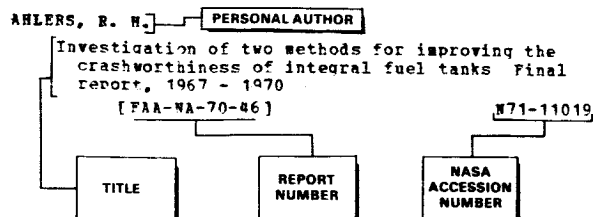
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